APPENDIX B

Loureiro Engineering Associates, Inc.
Standard Operating Procedures

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geoprobe® Probing and Sampling

SOP ID: 10011
Date Initiated: 11/10/94
Revision No. 006: 02/11/08

Approved By:	***/s/ David C. Brisson***	***02/11/08***
	David C. Brisson	**Date**
	Project Geologist	
	/s/ Nick D. Skoularikis	***02/11/08***
	Nick D. Skoularikis	**Date**
	Director of Quality	

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	11/10/94	
001-002	-	No record.
003	06/17/97	No record.
004	07/19/00	Revisions to template, including new logo. Revisions to Sections 3, 4, 5 and 6 in order to generalize sampling procedures and reference Geoprobe® Systems' catalog and specific soil sampling standard operating procedures.
005	12/31/01	Revisions made to reflect new SOP format. Addition of QA/QC section, minor changes throughout.
006	02/11/08	Added Appendix A: Macro-Core Soil Sampling; Revisions to Section 4.13.

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geoprobe® Probing and Sampling

1. Purpose and Scope

The objective of this standard operating procedure (SOP) is to collect discrete soil samples at depth using Geoprobe® probing and sampling methodologies and to recover the samples for visual inspection and/or analysis. Procedures for soil sampling for analysis are included in *Loureiro Engineering Associates* (*LEA) SOP for Soil Sampling*, SOP ID 10006.

2. Definitions

2.1. **Geoprobe â ***: A vehicle-mounted, hydraulically-powered, soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples.

*Geoprobe® is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.

2.2. **Sampler**: A piston type soil sampler capable of recovering a discrete sample in the form of a core contained inside a removable liner.

2.3. **Liner**: A removable/replaceable, thin-walled tube inserted inside the sampler body for the purpose of containing and storing soil samples. Liner materials include brass, stainless steel, Teflon®, and clear plastic (either PETG or cellulose acetate butyrate).

3. Equipment

The equipment required to recover soil core samples using the Geoprobe® samplers and driving system can be found in the Geoprobe® Systems catalog for tools and equipment, as referenced in Section 6. Sample liners for the Geoprobe® samplers are available in four different materials. Liner materials should be selected based on sampling purpose, analytical parameters, and data quality objectives. A listing of the general parts and equipment from the Geoprobe® Systems catalog for tools and equipment is provided below:

Geoprobe® Tools	Part Number
Probe Rod (4 Foot)	AT104B
Probe Rod (3 Foot)	AT10B
Probe Rod (2 Foot)	AT105B
Probe Rod (1 Foot)	AT106B
Drive Cap	AT11B
Pull Cap	AT12B
Extension Rod	AT67
Extension Rod Coupler	AT68
Extension Rod Handle	AT69
MC Drive Head	AT8510
MC Cutting Shoes	AT8530,8535,8537
MC Piston Tip Assembly	AT8570
MC Spacer Ring or Core Catcher	AT8531K,8532K
MC Sample Tube	AT8522
MC PETG Liner	AT825K
MC Combination Wrench	AT8590
MC Release Rod	AT8580
MC Extension Rod	AT671
Extension Rod Coupler	AT68
Ext. Rod Quick Links	AT694K
Ext. Rod Handle	AT69
MC Vinyl End Caps	AT726K
Liner Cutter Kit	AT8000K
Nylon Brush for Macro Tubes	BU700

4. Procedure

4.1. Utilities Clearance

4.1.1. Notify the appropriate "one call" utility notification service (e.g., in Connecticut, Call Before You Dig at 1-800-922-4455) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification. The Project Engineer/Manager **must** call and confirm that each utility has been to the site and has marked their respective lines.

4.1.2. On private sites, consult with the owner or other person knowledgeable about the site as to the locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the Project Engineer/Manager, a pipe locator can also be used to assist in locating utilities.

4.1.3. Note that the Occupational Safety and Health Administration (OSHA) may have additional requirements for location of utilities.

4.1.4. All efforts to locate underground utilities (including names of owner or designee and time) should be properly documented in the field logbook or field paperwork prior to onset of the work scheduled.

4.2. Health and Safety

The foreman or supervisor of the drilling crew shall be the competent person as required by OSHA for all of their work. However, this does not relieve any other LEA representative from bringing to his or her attention conditions which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site. The LEA representative is responsible for ensuring that LEA activities are conducted in accordance with the site-specific Health and Safety Plan.

Note specific health and safety guidance regarding the operation of the Macro-Core soil sampler provided in Appendix A.

4.3. Site Preparation

4.3.1. A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".

4.3.2. An equipment decontamination area shall be assembled as described in Section 4.14 within the exclusion zone.

4.3.3. All personal protective equipment as required in the site-specific health and safety plan shall be donned.

4.4. General Sampler Assembly

4.4.1. The sampler is connected to the leading end of a Geoprobe® probe rod and driven into the subsurface using a Geoprobe® drilling apparatus. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a reverse threaded stop pin at the trailing end of the sampler. The first four-foot interval does not require the piston tip assembly. In addition, if the borehole remains open, the piston tip assembly may not be required for deeper intervals. If there is evidence that the borehole is collapsing, the piston tip will be utilized.

4.4.2. When the sampler tip has reached the top of the desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. The extension rods are then rotated clockwise (using a handle). The male threads on the leading end of the extension rods engage the female threads on the top end of the stop pin, and the pin is removed.

4.4.3. After the extension rods and stop pin have been removed, the tool string is advanced an additional 24 to 48 inches (depending on the soil sampling system in use). The piston is displaced inside the sampler body by the soil as the sample is cut. To recover the sample, the sampler is recovered from the hole and the liner containing the soil sample is removed.

4.4.4. Refer to the Geoprobe® System standard operating procedures for operation of various soil sampling systems (e.g., Macro Core Piston Rod Soil Sampling System, DT21 Dual Tube Soil Sampling System, Large Bore Soil Sampling System).

4.5. Pilot Hole

A pilot hole is appropriate when the surface to be penetrated contains gravel, asphalt, hard sand, or rubble. Preprobing can prevent unnecessary wear on the sampling tools. A specific Geoprobe® preprobe may be used for this purpose. The pilot hole should be made only to a depth above the sampling interval. Where surface pavements are present, a hole may be drilled with the Geoprobe® using a specific drill steel bit (AT-32, -33, -34, or -35, depending upon the thickness of the pavement), tipped with a 1.5 inch diameter carbide drill bit (AT-36) prior to probing. For pavements in excess of 6 inches, the use of compressed air to remove cuttings is recommended.

4.6. Concrete Coring

Should the borehole be located on concrete, the Geoprobe® can be used to core through the concrete to gain access to the underlying soil. A carbide-tipped drill bit (AT36-39) and Geoprobe® drill steel (AT3524, 3536, 3548) will be attached to the drill assembly and utilized to core the concrete. For concrete in excess of 16 inches, other methods (i.e., a core saw) should be utilized to penetrate the concrete.

4.7. Driving

4.7.1. Attach a probe rod to the assembled sampler and a drive cap to the probe rod. Position the assembly for driving into the subsurface. Make sure the assembled sampler is relatively perpendicular to the ground surface. A level can be utilized if drilling on uneven ground.

4.7.2. Drive the assembly into the subsurface until the drive head of the sample tube is just above the ground surface.

4.7.3. Remove the drive cap and the probe rod. Secure the drive head with a 1-inch or adjustable wrench and retighten the stop pin with a 3/8-inch wrench.

4.7.4. Attach a 2-foot probe rod and a drive cap, and continue to drive the sampler into the ground. Attach 3-foot probe rods in succession until the leading end of the sampler reaches the top of the desired sampling interval.

4.8. Preparing to Sample

Specific instructions and photographic documentation for sampling with the Macro-Core soil sampler are provided in Appendix A.

4.8.1. When the sampling depth has been reached, position the Geoprobe® machine away from the top of the probe rod to allow room to work.

4.8.2. Insert an extension rod down the inside diameter of the probe rods. Hold onto it and place an extension rod coupler on the top threads of the extension rod (the down hole end of the leading extension rod should remain uncovered). Attach another extension rod to the coupler and lower the jointed rods down-hole.

4.8.3. Couple additional extension rods together in the same fashion as in Step 2. Use the same number of extension rods as there are probe rods in the ground. The leading extension rod must reach the stop-pin at the top of the sampler assembly. When coupling extension rods together, you may opt to use the extension rod jig to hold the down-hole extension rods while adding additional rods.

4.8.4. When the leading extension rod has reached the stop pin down-hole, attach the extension rod handle to the top extension rod.

4.8.5. Turn the handle clockwise (right handed) until the stop pin detaches from the threads on the drive head. Pull up lightly on the extension rods during this procedure to check thread engagement.

4.8.6. Remove the extension rods and uncouple the sections as each joint is pulled from the hole. The extension rod jig may be used to hold the rod couplers in place as the top extension rods are removed.

4.8.7. The stop pin should be attached to the bottom of the last extension rod upon removal. Inspect it for damage. Once the stop pin has been removed, the sampler is ready to be redriven to collect a sample.

4.9. Sample Collection

4.9.1. Reposition the Geoprobe® machine over the probe rods, adding an additional probe rod to the tool string if necessary. Make a mark on the probe rod 24 inches above the ground surface (this is the distance the tool string will be advanced).

4.9.2. Attach a drive cap to the probe rod and drive the tool string and sampler another 24 inches. Use of the Geoprobe®'s hammer function during sample collection may increase the sample recovery in certain formations. Do not overdrive the sampler.

4.10. Retrieval

4.10.1. Remove the drive cap on the top probe rod and attach a pull cap. Lower the probe shell and close the hammer latch over the pull cap.

4.10.2. With the Geoprobe® foot firmly on the ground, pull the tool string out of the hole. Stop when the top (drive head) of the sampler is about 12 inches above the ground surface.

4.10.3. Because the piston tip and rod have been displaced inside the sample tube, the piston rod now extends into the 2-foot probe rod section. In loose soils, the 2-foot probe rod and sampler may be recovered as one piece by using the foot control to lift the sampler the remaining distance out of the hole.

4.10.4. If excessive resistance is encountered while attempting to lift the sampler and probe rod out of the hole using the foot control, unscrew the drive head from the sampler and remove it with the probe rod, the piston rod and the piston tip. Replace the drive head onto the sampler and attach a pull cap to it. Lower the probe shell and close the hammer latch over the pull cap and pull the sampler the remaining distance out of the hole with the probe machine foot firmly on the ground.

4.11. Sample Recovery

4.11.1. Detach the 2-foot probe rod if it has not been done previously.

4.11.2. Unscrew the cutting shoe using the cutting shoe wrench, if necessary. Pull the cutting shoe out with the liner attached. If the liner doesn't slide out readily with the cutting shoe, take off the drive head and push down on the sidewall of the liner. The liner and sample should slide out easily.

4.12. Core Liner Capping

4.12.1. The ends of the liners can be capped off using the vinyl end cap for further storage or transportation. A black end cap should be used at the bottom (down end) of the sample core and a red end cap at the top (up end) of the core.

4.12.2. On brass, stainless steel, and Teflon® liners, cover the end of the sample tube with Teflon® tape before placing the end caps on the liner. The tape should be smoothed out and pressed over the end of the soil core so as to minimize headspace. However, care should be taken not to stretch and, therefore, thin the Teflon® tape.

4.12.3. The soil boring identifier and depth of sample should be marked at the top of the core (on the red end cap).

4.13. Sample Removal

4.13.1. To facilitate sample removal, each vinyl end cap can be slid off or, if there is resistance, they can be slit using a utility knife with a carpet blade. To cut vinyl end cap, slide blade under edge of cap at shallow angle and rotate the blade until cutting edge begins to cut the vinyl cap, and then draw the knife slowly toward the end of the cap. As the friction is reduced the end cap may move with the knife and become free of the sample liner.

4.13.2. Clear plastic and Teflon® liners can be slit open easily with a utility knife for the samples to be analyzed or placed in appropriate containers.

4.13.3. Brass and stainless steel liners separate into four 6 inch sections. The manual extruder may be used to push the soil cores out of the liner sections for analysis or for transfer to other containers.

4.13.4. The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling*.

4.13.5. Soil samples collected for archive purposes shall be placed into soil jars and labeled with sample numbers, date, time, and LEA commission number.

4.14. Equipment Decontamination and Cleaning

4.14.1. Prior to conducting a boring, the LEA representative will ensure that all necessary equipment is clean and decontaminated, including the rig, all augers and probing equipment, samplers, brushes, and any other tools or equipment. Decontamination procedures may vary slightly from those presented below, dependent upon the particular types of contaminants encountered.

4.14.2. A section of 5 mil (minimum) plastic sheeting shall be cut of sufficient size to underlie the decontamination area to contain any discharge of decontamination solutions.

4.14.3. The following solutions (as appropriate for the anticipated contaminants) shall be prepared and placed in 500 ml laboratory squirt bottles:

- Methanol solution in water (less than 10 percent).
- 10 percent nitric acid solution in water (less than 10 percent).
- 100 percent hexane solution (to be used only if separate-phase petroleum product, other than gasoline, is present).
- Distilled deionized (DI) water.

4.14.4. A fifth solution of phosphate-free detergent and tap water (approximately 2.5 gallons) shall be prepared in a five-gallon bucket. Only those solutions required for site-specific conditions will be used at a given site, as specified in the site-specific work plan.

4.14.5. All loose debris shall be removed from the augers and spatulas into an empty 5-gallon bucket or plastic sheeting using a stiff bristled brush.

4.14.6. The order of decontamination solutions is as follows:

- Detergent scrub.
- Distilled water rinse.
- Hexane rinse (to be used only if separate-phase petroleum product, other than gasoline, is present).
- Distilled water rinse.
- 10 percent nitric acid rinse (to be used only when metals are suspected as potential contaminants).
- Distilled water rinse.
- Methanol rinse (less than 10 percent solution).
- Air dry.

4.14.7. All sampling equipment shall be decontaminated at the beginning of each project, in between sample collection, and at the completion of the project.

4.14.8. An alternative to the procedure described above requires that the larger equipment be cleaned using a high-pressure wash and steam cleaning in an area constructed to contain spent decontamination fluid and debris (plastic sheeting bermed with timber is usually sufficient). Alternative methods of cleaning may be more appropriate for an individual piece of equipment for site conditions based upon knowledge of site contaminants, and may be used at the discretion of the LEA representative. Section 4.19 provides additional information on management of potentially contaminated fluids and materials.

4.14.9. At the end of the project day, all used equipment shall be decontaminated. All spent decontamination solutions will be handled and disposed of in accordance with all applicable municipal, state and federal regulations.

4.15. VOC Monitoring

4.15.1. A portable volatile organic compound (VOC) analyzer equipped with a photoionization detector (PID) or flame ionization detector (FID) shall be available on site and shall be used to screen all cuttings and fluids (if any) removed from the hole.

4.15.2. Since, in general, it cannot be presumed that there is no contamination at a given site, all cuttings and/or fluids which show a reading on the VOC analyzer that is above background shall be containerized or drummed, as appropriate, on site. The soil cuttings should be containerized if the presence of other contaminants (such as metals, semivolatile organic compounds) is known or suspected. Additional information on management of potentially contaminated fluids and materials is presented in Section 4.19.

4.16. Sample Collection and Documentation

The following procedures will be followed for sample collection following removal from the borehole.

4.16.1. The sample tube shall be opened by the LEA representative and immediately scanned using the VOC analyzer using the approach described in Section 4.17.

4.16.2. The LEA representative will record on the boring log information described in Section 4.18.2.

4.16.3. Prior to reuse, the sampler shall be decontaminated using the procedures described in Section 4.14.

4.16.4. Soil samples collected for archival purposes shall be placed into soil jars and labeled with the sample number, date, time, and LEA commission number.

4.16.5. The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling*.

4.17. Field Analysis

4.17.1. The following procedure shall be used to obtain readings with a portable VOC analyzer of the VOCs present in a soil sample:

- Obtain an aliquot of soil (approximately 50 grams) from the split spoon and placed into a plastic bag or equivalent and sealed.
- Agitate the sample, assuring that all soil aggregates are broken, for at least two minutes.
- Carefully break the seal of the bag enough to insert the VOC probe.
- Record the maximum reading obtained on the appropriate forms, as described in Section 4.18.

4.18. Field Documentation

4.18.1. The following general information shall be recorded in the field log book and /or appropriate field forms:

- Project and site identification.
- LEA commission number.
- Field personnel.
- Name of recorder.
- Identification of borings.
- Collection method.
- Date and time of collection.
- Types of sample containers used, sample identification numbers and QA/QC sample identification.
- Field analysis method(s).
- Field observations on sampling event.
- Name of collector.
- Climatic conditions, including air temperature.
- Chronological events of the day.
- Status of total production.
- Record of non-productive time.
- QA/QC data.
- Name of drilling firm.
- Location of boring(s) on site in sufficient detail to relocate boring at a future time (include sketch).

4.18.2. The following information shall be recorded in the boring log:

- Project name, location, and LEA commission number.
- Borehole number, borehole diameter, boring location, drilling method, contractor, groundwater observations, logger's name and date.
- Depth below grade, sample number, duplicate numbers, VOC analyzer reading, rig behavior (i.e., drilling effort, etc.).
- A complete sample description following SOP ID 10015, *Geologic Logging of Unconsolidated Sedimentary Deposits.* This will include, as a minimum: depth, material size gradation using the Burmister system, color, moisture, and density. Should a well be constructed in a borehole, a complete well schematic shall be drawn and accurately labeled.
- Use of water, including source(s) and quantity.

4.18.3. The following information shall be recorded on the QA Checklist provided in the Daily Field Report:

- Review of all necessary site activities and field forms.
- Statement of corrective actions for deficiencies.

4.18.4. Any instrument calibration information shall be recorded in the "Instrument Calibration" section provided in the Daily Field Report, and shall include the following information:

- Instrument make, model, and type.
- Calibration readings.
- Standards and backgrounds used for calibration.

4.19. Disposal of Potentially Contaminated Materials

Potentially contaminated cuttings or fluids, as indicated by knowledge of the site, discoloration, VOC analyzer readings, or other evidence, shall be containerized on-site pending sampling and determination of hazardous waste status.

4.20. Refusal

Refusal is defined as failure to penetrate the subsurface materials to any greater depth using the maximum reasonable pressure limits of the Geoprobe® machine.

4.21. Bedrock

The term "bedrock" will not be used in a boring log or other description of subsurface materials that have been collected using the Geoprobe® machine, since a confirmatory core cannot be collected.

4.22. Boring Abandonment

4.22.1. If the boring is not to be used for other purposes (i.e., monitoring well, soil vapor probe, soil vapor extraction well, etc.) it shall be abandoned.

4.22.2. The boring shall be filled and sealed with neat cement grout or high-density bentonite clay grout as soon as the tools are withdrawn from the borehole.

4.22.3. Excess cuttings shall be containerized, labeled and the analytical data of the contents reviewed/profiled before disposal.

4.22.4. In paved areas, the upper three feet of the borehole shall be filled, up to two inches below the existing grade, to allow for repairing of the pavement.

4.22.5. Pavement shall be repaired using cold patch asphalt filler or concrete.

5. Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) procedures shall comply with the procedures described in LEA SOP ID 10004. QA/QC samples, if required, (including performance evaluation samples, equipment blank samples, trip blank samples, and field duplicate samples) shall be collected according to the site-specific work plan.

6. References

6.1. Geoprobe® Systems, 1997, *1998-1999 Tools and Equipment Catalog*.

6.2. Geoprobe® Systems, *Geoprobeâ Macro-Core Soil Sampler Standard Operating Procedure*, Technical Bulletin No. 95-8500, prepared 11/95, as revised.

6.3. Geoprobe® Systems, *Geoprobeâ DT21 Dual Tube Soil Sampling System, Continuous Core Soil Sampler Standard Operating Procedure*, Technical Bulletin No. 982100, 09/98.

6.4. Geoprobe® Systems, *Geoprobeâ Large Bore Soil Sampler, Discrete Interval Soil Sampler Standard Operating Procedure*, Technical Bulletin No. 93-660, prepared 09/96, revised 04/98.

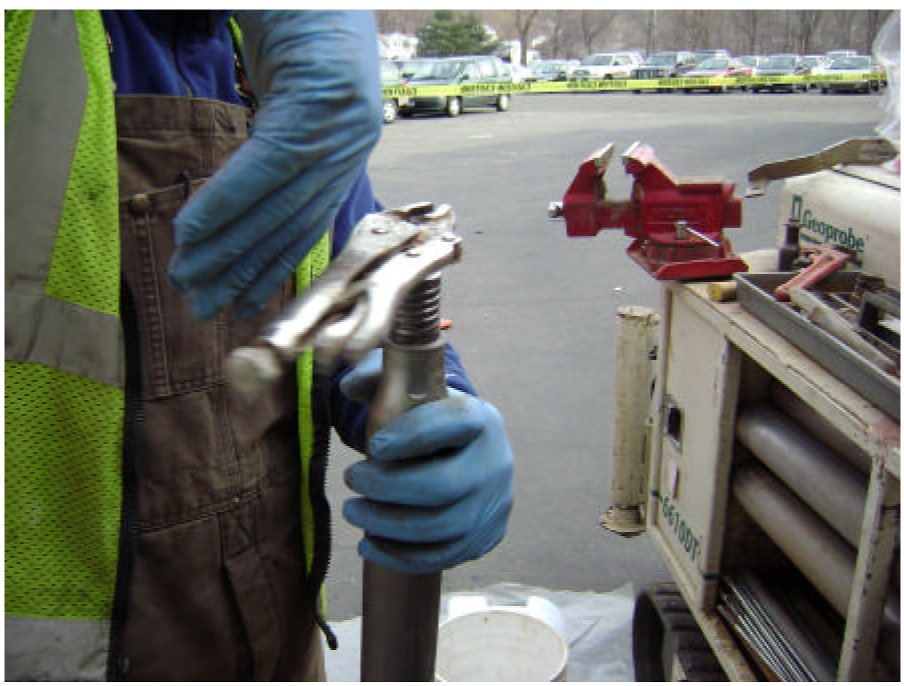
END OF DOCUMENT

Appendix A

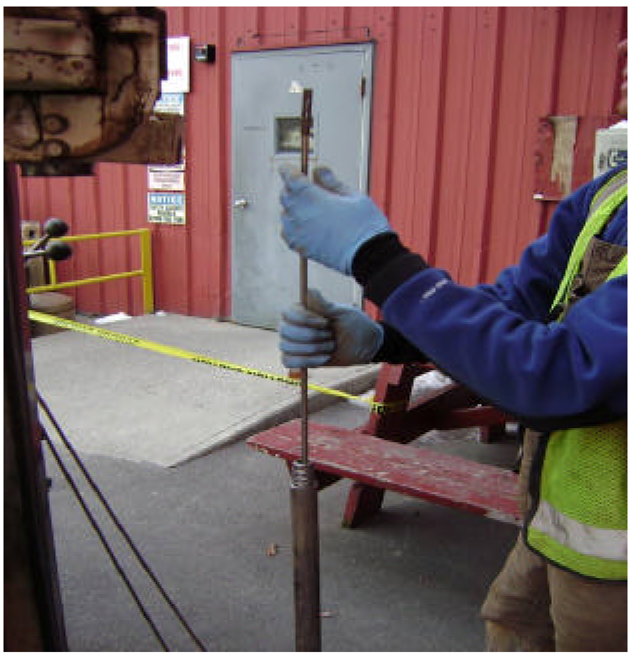
Soil Sampling Practices with Macro-Core Soil Sampler

In the top photo the worker is tapping the internal threads of the drive head into which the Macro-Core (MC) Stop-Pin assembly will be screwed. This task is necessary as the threads tend to become distorted over time due to the constant pounding they endure. **IMPORTANT**: This is one of the most crucial steps in the MC Piston Rod assembly process as it increases the likelihood that the Stop-Pin assembly will easily disengage (unscrew) when it comes time to remove it so that the point assembly can be released and the soil sample obtained. It must be performed each time that the MC system is assembled. The external threads on the drive head and drill casings also need to be maintained on a regular basis. Brushing the threads before each use helps to keep the threads clean and free of built-up dirt. A little Crisco shortening on the threads also seems to help keep them from binding up.

In these photos the focus is on the cutting shoe and the piston rod point assembly. As is the case for all of the equipment, the cutting shoe and piston rod point assembly need to be in very good condition. The key is that once assembled the piston rod point must extend out beyond the lip on the cutting shoe. The rod point should also fit tightly into the cutting shoe. If not it is likely that dirt will push up around the piston point and up into the cutting shoe. This will put unwanted pressure on the MC piston rod making it unlikely that the MC Stop-Pin assembly will unscrew easily when the time comes to remove it. **IMPORTANT:** Keep in mind that when the soil sampling system is in the ground upward pressure is being placed on the piston rod point, which puts pressure on the MC piston rod which in turn puts pressure on the MC Stop-Pin Assembly. Thus before you try to remove the MC Piston Rod make sure that you raise the entire system an inch or so to take pressure off of the piston rod point.



Once the MC piston rod is inserted into the sample tube a pair of Vise-Grips is usually attached to the MC Extension Rod Quick Link Connector (the end of the rod) and used to screw in the MC Stop-Pin assembly. Geoprobe® does offer tools for this task, however it is felt that these tools have handles that are too short and as such do not provide enough leverage. **IMPORTANT:** Once the stop pin is fully tightened back it off slightly by about 10 degrees. This is yet another crucial step that will increase the likelihood of the piston rod coming out easily.



Note the worker holding the pipe wrench in the top left photo. This is used to prevent the sample tube from falling down the hole. It is often wrested atop the operator's foot or the Geoprobe® foot. Steel-toed boots really help in this case. One word of caution, you should avoid placing your fingers between the wrench and the ground as shown in the top left photo. In the next several photos extension rods with Quick Link couplers are being inserted so that the MC Piston Rod can be removed. Once again Vise-Grips are the tool of choice for unscrewing the MC Piston Rod. If we have done all of our preventative maintenance the MC Piston Rod should unscrew with minimal effort. Some force might be needed to "pop" it loose but not too much.

IMPORTANT: When you are sampling at greater depths you will have to use several extension rods to get the MC Piston Rod out. Keep in mind that these smaller diameter extension rods tend to torque as you try to unscrew the MC Piston Rod. Should you let go under these conditions the extension rods and any tool (Vise-Grip) attached to them are going to want to “unwind” and “snap back”. This could result in a part of your body getting smacked by the Vise-Grip with the potential for injury being very high. To prevent this never apply excessive force when trying to disengage (unscrew) the piston rod and never simply let go of the Vise-Grip after applying force. If the piston rod does not unscrew easily the safest decision is to pull up the sample tubes a section at a time until you can work directly on the MC Piston Rod and MC Stop-Pin Assembly directly.

(This information can be found in greater detail in Geoprobe’s® Technical Bulletin No. 95-8500)

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Soil Sampling

SOP ID: 10006
Date Initiated: 02/20/90
Revision No. 009: 01/18/06

Approved By: ______________________ ***01/18/06***
David Brisson **Date**
Senior Project Geologist

______________________ ***01/18/06***
Nick D. Skoularikis **Date**
Director of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	02/20/90	
001-004	-	No record.
005	07/19/00	Revisions to template, including new logo.
006	05/16/01	Revisions to Sections 4.2.1, 4.2.2; add Section 4.2.3.
007	07/27/01	Updated to conform with new SOP format.
008	12/31/01	Minor revisions throughout.
009	01/18/06	Removed use of wood spatula

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Soil Sampling

1. Purpose and Scope

This document discusses procedures for collection of soil samples for analysis. Methods for collection and quality assurance/quality control (QA/QC) requirements are covered under separate standard operating procedures (SOPs). The procedures outlined in this document are in accordance with American Society of Testing Materials (ASTM) Standard D 420 and the Environmental Protection Agency (EPA) document entitled, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846). These procedures may vary slightly according to project-specific requirements.

2. Definitions

2.1. Field Forms: For the purpose of document and data control, a form is a document used in the conduct of company business to collect data, including approvals where required. Completed forms providing objective evidence of quality related activities are retained as quality records.

3. Equipment

3.1. Equipment required for the collection of soil samples shall include:

- Stainless steel spatula.
- Decontamination solutions, including distilled water, 10 percent methanol, 10 percent nitric acid.
- Hand towels.
- Polyethylene plastic sheeting.
- Sample collection jars.
- Clean disposable gloves.
- Field documentation.
- Indelible ink marker.
- Cooler, cold packs.
- Chain of custody seals and sample labels.
- Balance for weighing samples (for samples collected for the Loureiro Engineering Associates, Inc. (LEA) Analytical Laboratory, if needed).
- Utility knife.

- Re-sealable plastic bags.

4. Procedures

4.1. Preliminary Sampling Procedures

4.1.1. Sample Bottles

4.1.1.1. A laboratory request form shall be completed and submitted to the laboratory with the following information:

- Project name.
- LEA commission number.
- Date of submittal and date needed.
- Quantity of sample locations and sample points at each location.
- Type(s) of samples.
- Analytes, detection limits and QA/QC needed.
- Cooler(s) required.
- Number of chain of custody forms requested.

4.1.1.2. Check bottles against laboratory request form for completeness. The bottles should also be checked for damage and cleanliness. Confirm with laboratory personnel the adequacy of the preservatives used.

4.1.1.3. The total number of sample sets shall be increased by 10 percent to allow for possible breakage during transport to sites or other contingencies. At a minimum one additional sample bottle set shall be obtained per event.

4.1.1.4. Obtain preprinted labels and paperwork through the LEA information management system.

4.1.1.5. Label/date bottles in the field prior to sample collection. Check for accuracy.

4.1.1.6. A cooler with adequate ice or cold packs should be obtained from the laboratory to insure that the collected samples remain at 4 degrees Celsius during transport. Packing material should also be obtained to insure against breakage during transport.

4.1.2. Site Preparation

4.1.2.1. A level table shall be placed within the exclusion zone and covered with polyethylene sheeting.

4.1.2.2. Decontaminated spatulas shall be placed on the table. Sample bottles shall be placed in a convenient location and in order of sample collection.

4.1.2.3. PID and plastic bags shall be placed on the table for VOC screening, if necessary.

4.2. Cleaning and Decontamination

4.2.1. Prior to collecting a soil sample, the LEA representative will ensure that all necessary sampling equipment is clean and decontaminated according to the procedure outlined in Section 4.2.3 or according to the site specific work plan if different than below.

4.2.2. Upon completion of all sampling requirements and prior to leaving the site, all equipment used for sampling shall be cleaned and decontaminated according to the procedure outlined in Section 4.2.3 or according to the site specific work plan if different than below. All generated decontamination fluids shall be containerized and disposed of in accordance with the site-specific work plan and all municipal, state, and federal requirements.

4.2.3. The decontamination procedure of durable sampling equipment will be accomplished via swabbing the surfaces with a solvent. The order of decontamination is as follows:

- Detergent swab.
- DI water rinse.
- Hexane rinse (to be used if separate-phase petroleum product, other than gasoline is present).
- DI water rinse.
- 10 percent nitric acid rinse (to be used only when metals are suspected as potential contaminants).
- DI water rinse.
- Methanol rinse (less than 10 percent solution).
- Air dry.

4.3. Sampling Procedures

4.3.1. All personal protective equipment (PPE) should be donned and maintained in accordance with the site-specific work plan or health and safety plan during all sampling procedures. In the event that no PPE has been specified for a particular sampling event, disposable latex gloves should be donned, as a minimum, during all sampling procedures.

4.3.2. The particular soil sampling device (i.e., hand auger, split spoon, etc.) shall be retrieved from the point of collection and placed on a level table covered in polyethylene sheeting.

4.3.3. Using a decontaminated stainless steel spatula, the soil shall be transferred directly into soil sampling containers. Care should be taken to completely fill the sample container intended for VOC analysis. Large void spaces within the container shall be minimized by packing, not agitation.

4.3.4. Wipe the rim of the sample container with a clean paper towel to remove excess solids, which would prevent adequate sealing of the sample container and seal the container.

The order of sample collection shall be as follows:

- Samples to be analyzed for volatile organic compounds (VOCs) at the LEA Analytical Laboratory.
- Samples to be analyzed for VOCs using appropriate EPA methodologies.
- Samples to be screened for total VOCs with a total volatile organic analyzer.
- Samples to be analyzed for other organic and inorganic constituents.

4.3.5. As required, affix a custody seal, noting the date and time of collection across the cap/bottle interface and on the sample label. Place and secure sample within cooler and complete all sample collection documentation. Alternatively, a custody seal shall be used to seal the entire cooler rather than individual sample containers.

4.4. Post Sampling Procedures

4.4.1. As required, upon completion of all sampling procedures for a particular site, secure the lid of the cooler using packaging tape with the chain of custody inside.

4.4.2. If the laboratory is local, transport the samples directly to the laboratory and present them to the sample manager. The representative of LEA should witness the verification of the chain of custody and obtain a carbon copy for filing in the project notebook.

4.4.3. If the laboratory is distant, arrange for transport with a reputable carrier service. Typically, the laboratory specifies the carrier to be used and provides the shipping papers. The cooler and samples shall be secured for transport, and all mailing documentation secured onto the top of the cooler. Unless otherwise specified, delivery shall be overnight. Friday shipments should be mailed for Saturday delivery, once confirmed that the laboratory can accept them on Saturday. The laboratory shall provide confirmation of acceptance noting the temperature of the temperature blank and any deviations from the chain of custody.

4.5. Documentation

4.5.1. The following general information shall be recorded in the field log book and/or on the appropriate field forms:

- Project and site identification.
- LEA commission number.
- Field personnel.
- Name of recorder.
- Identification of borings.
- Collection method.
- Date and time of collection.
- Types of sample containers used, sample identification numbers and QA/QC sample identification.
- Preservative(s) used.
- Parameters requested for analysis.
- Field analysis method(s).
- Field observations on sampling event.
- Name of collector.
- Climatic conditions, including air temperature.
- Internal temperature of field and shipping (cooled) containers.

- Chronological events of the day.
- Status of total production.
- Record of non productive time.
- QA/QC data.

4.5.2. The following information shall be recorded on the Daily Field Report QA Checklist:

- Reviewer's name, date, and LEA commission number.
- Review of all necessary site activities and field forms.
- Statement of corrective actions for deficiencies.

4.5.3. The following information shall be recorded on the chain of custody record:

- Client's name and location.
- Date and time of sample collection.
- Sample number.
- Container type, number, size.
- Preservative used.
- Signature of collector.
- Signatures of persons involved in the chain of possession.
- Analyses to be performed.
- Type and number of samples.

4.5.4. The following information shall be provided on the sample label using an indelible ink pen:

- Sample identification number.
- Date and time of collection.
- Place of collection.
- Parameter(s) requested (if space permits).

4.5.5. The following information shall be recorded on the sample collection data sheet:

- Client name, location and LEA commission number.
- Boring or sampling location identification number.
- Date and time of collection.
- Sample number.
- Depth sample was obtained.
- Field instrumentation reading.

5. Quality Assurance/Quality Control

5.1. One trip blank sample should accompany the sampling set for each field crew and each field day for which VOC samples are collected.

5.2. One equipment blank sample should be collected for each field crew and each field day. Equipment blank samples should be analyzed for the same suite of analytes as the soil samples.

5.3. For QA/QC purposes, one duplicate sample will be collected for every twenty samples. The duplicate sample set will be analyzed for the same suite of analytes as the soil samples.

6. References

6.1. ASTM Standard D 420

6.2. EPA, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846).

END OF DOCUMENT

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials

SOP ID: 10015
Date Initiated: 12/27/94
Revision No. 002: 01/15/02

Approved By: ***/s/ Kimberly C. Clarke*** ***01/15/02***
Kimberly C. Clarke **Date**
Senior Project Scientist

/s/ Nick D. Skoularikis ***01/15/02***
Nick D. Skoularikis **Date**
Director Of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	12/27/94	
001	11/20/96	No record.
002	01/15/02	Formatting and minor revisions throughout.

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials

1. Purpose and Scope

This document presents the methods and procedures used to describe unconsolidated sedimentary materials for geological purposes in a uniform and consistent manner. It includes procedures for properly recording the observations by providing guidelines for completing boring logs and submitting those logs for computer entry. This Standard Operating Procedure (SOP) refers only to geologic logging of soils and sediments (including artificial fill and other man-made deposits) and specifically is not intended to describe logging of soils or sediments for geotechnical or other engineering purposes. Although the SOP presents a system for describing sediments, it is not intended to be a definitive reference for classifying sedimentary materials, nor is it intended to replace experience or training. Individuals using this SOP should be trained and competent in field methodologies and geologic logging prior to commencing field activities.

2. Definitions

2.1. None

3. Equipment

3.1. Equipment required for the geologic logging of soil/sediment samples shall include the following items:

- Tape measure or scale.
- Hand lens.
- Color chart.
- Grain-size comparator.
- Field forms.
- Indelible marker(s).
- Small table.
- Field Paperwork.
- Clipboard.

4. Procedures

4.1. Sample Collection

Samples of soil and unconsolidated sedimentary materials will be collected in general accordance with the SOPs for Soil Sampling (SOP ID 10006), Hand Auger Borings (SOP ID 10003), Hollow Stem Auger Soil Borings (SOP ID 10008), and Geoprobe® Probing and Sampling (SOP ID 10011). Those SOPs include procedures for decontamination of equipment required for sample collection, as well as providing the methodologies for sample collection and documentation.

4.2. Descriptions of Unconsolidated Sedimentary Materials

4.2.1. General Sediment Description Guidelines

For the purposes of geologically logging unconsolidated soils and sedimentary materials, a Modified Burmister method of description and classification should be used. The Modified Burmister Sediment Classification System (or simply, Burmister System) is intended as a rapid field method for identifying and classifying sediments. The system is based upon visual identification of the generalized grain-size distribution and description of the physical characteristics of the sample.

A Burmister System description is comprised of three parts: a color descriptor; a grain-size descriptor; and modifier(s). The color descriptor indicates the overall color or colors of the wet sample. The descriptor consists of a color name or names and (if possible) the color code from a standard color reference (for example, a Munsell[7] Color Chart). The grain-size description indicates the predominant grain size in the sample, as well as the relative percentages of other grain sizes present.

Modifiers are used to further describe the geologic character of the sample. Modifiers may include descriptions of moisture content, sorting, sphericity, angularity, sedimentary structures or other pertinent information.

4.2.2. Color Description

The color of the wet sediment should be determined with reference to a standard color comparator (for example, a Munsell[7] Color Chart) for rocks or sediment. The included color descriptor should contain both the color name and, when a color comparator is used, the appropriate hue-chroma value code, for example "Reddish brown (5YR 4/4)". The color of a sample should always be gauged when the sample is wet, or it should be noted otherwise.

4.2.3. Predominant Grain-Size Description

The first step in describing a sediment sample is visually estimating the size range and percentage of the various grain sizes in the sample. Reference should be made to standard geologic comparators for assessment of the grain size(s).

The primary grain-size descriptor indicates the predominant grain size, as judged visually, of the sample. The descriptor is always capitalized and underlined. Possible descriptors include: CLAY, SILT, SAND, and GRAVEL (GRANULES, PEBBLES, COBBLES, and BOULDERS). These correspond to the standard Wentworth size-classification scheme used for describing sediments for geologic purposes. Size classifications for CLAY through GRAVEL are presented in Table 1. The descriptor should also include an indication of the relative size range of the sample within the predominant grain size (for example, "fine-to-medium sand", "coarse sand", etc.). Although Table 1 includes divisions of the silt category, this is applicable only to sediment samples analyzed by pipette or hydrometer and cannot be distinguished in the field.

The presence of other grain sizes, in addition to the predominant material is also included in the grain-size descriptor. Appropriate grain sizes are the same as for the predominant grain size of the material (clay, silt, etc.), however only the initial letter of the word is capitalized. The description should also include an indication of the relative amount of the minor components. Appropriate indicators for the relative percentages present are provided in Table 2.

It is generally not considered possible to visually distinguish between clay and silt. Estimation of the silt/clay content of a sample should be based upon the plastic properties of the sample. The plastic properties of the sample may be estimated by taking an approximately 1 cubic centimeter ball of the sediment and attempting to roll a thread of the material between the palms of the hand. The minimum size of the thread which may be rolled may be compared to the values presented in Table 3 and the plasticity estimated. A comparison of the minimum thread diameter which may be formed with the information presented in Table 3 provides an approximate silt/clay content estimate for sand-silt-clay sediments and composite clay sediments.

4.2.4. Modifiers

Various modifiers may be added to the basic sediment description to further describe the geologic character of the sample.

For sand or coarser-sized material, the relative degree of sorting, the sphericity, and angularity should also be recorded. Sorting may be visually estimated. Sphericity and angularity, however, should be made with reference to an accepted comparator. A chart illustrating various degrees of sphericity and angularity is attached as Figure 1.

The mineralogy of the sample should also be recorded. Reference should be made to the relative percentages, grain size(s), and sphericity of the mineral particles (especially where it differs significantly from that of the predominant grain-size material).

Other information which should be recorded for each sample includes an estimate of the density and cohesiveness of the sample (made from blow counts where applicable, or other specific instrumentation where appropriate), the relative moisture content of the sample, visible sedimentary structures, and any odors or staining noticeable during logging. Tables 3 and 4 present appropriate terms for describing the plasticity, density, and cohesiveness of sediment samples.

Especially important is an indication that a specific portion of the material may represent "sluff" or material collapsed from the borehole walls.

4.3. Written Sediment Descriptions

The written sediment description may be made as either an unabbreviated or an abbreviated description. Both methods should relate the same information, however the abbreviated description is better suited for field use.

In an unabbreviated description, all of the words of the description should be written out in their entirety. The descriptor should include pertinent information regarding the sample's size gradation, consistency, color, and relative grain size, as described previously. The color descriptor should precede the primary sediment component name, while additional details such as the plasticity, mineralogy, visible sedimentary structures, etc., should follow the sediment component name.

An example of an unabbreviated description is:

Red-brown (5YR 4/4), fine to coarse SAND, little fine Gravel, little Silt, moist, moderately well sorted, low sphericity, Gravel waterworn, Sand subangular, micaceous.

Since the Burmister system is intended to provide a means for describing uniform sediments, three "special" cases should be addressed.

First, the Burmister system is intended only to describe the sediment. Where a genetic classification of the material is significant, it should be added as a separate statement at the end of the description. For example:

> **Olive gray (5Y 4/2), coarse to fine SAND, some fine Gravel, little Silt, moist, poorly sorted, sub-rounded to angular, dense. TILL.**

A genetic classification should only be used when the origin of the material is very clear and not simply a field interpretation of possible depositional environment.

Second, in the case where the sediment sample is heterogeneous (for example, a varved silt and clay), each component should be described individually, and reference should be made to the relative percentages of each component and to the interlayering. For example:

> **Soft, reddish-brown (5YR 3/4), CLAY and SILT, alternately layered, medium to high overall plasticity. Layers: CLAY layers, 3/8" to 5/8" thick, comprise 60%" of sample. SILT layers, 1/8" to 3/8" thick, comprise 40%" of sample. VARVED CLAY and SILT.**

Third, when one material grades uniformly into a distinct sediment type, the individual components should be described separately and the gradation noted. For example:

> **Soft, reddish-brown (5YR 3/4), CLAY, medium overall plasticity, grading into soft, reddish-brown (5YR 4/4), SILT, trace Clay, low overall plasticity.**

In the abbreviated sediment descriptions, the sample information is presented in a manner analogous to that for the unabbreviated description substituting standard abbreviations for specific portions of the text. Abbreviations for the identifying terms in the Burmister system are presented in Tables 2, 3, and 4. Mineralogic and geologic abbreviations may be found in standard geologic and mineralogic texts and field manuals. Except for the use of abbreviations, the abbreviated description is completely analogous to the unabbreviated description.

For the sake of consistency in describing unconsolidated sedimentary materials, the description should follow the order and general definitions presented in Table 5.

4.4. Recording Descriptions

4.4.1. Geologic Boring Logs

Attached to this SOP is a copy of LEA's standard geologic boring log form. This log should be completed for each boring that is completed. The heading information is self-explanatory. The body of the log contains space for information for each sampled interval in the boring. The following information should be recorded:

Depth Interval	The upper and lower depths from which the sample was collected.
Sample No.	The sample number, as obtained from LEA Data Management, assigned to this sample.
Recovery	The length of the recovered sample and the length of the sampler (in consistent units). The percent recovery will be calculated by the LEA Data Management program.
Blows/6"	The number of blow counts per 6" interval for the sample. Alternately, the downhole pressure or other pertinent information regarding the required drilling or sampling force.
Sample Description	The sample description using the guidelines and order presented in Section 3.0 and Table 5.
PID/FID	The headspace reading from a PID or FID in ppm.

The comments section of the form should be used to record general observations regarding drilling conditions, backfilling of the borehole, or other pertinent information regarding drilling the borehole.

4.5. Computer Data Entry

After a project is completed, copies of the Geologic Boring Log forms should be submitted for computer data entry. A completed copy of the Geologic Soil Boring/well Completion Log Request Form should be attached to the log forms.

5. Quality Assurance/Quality Control

5.1. Soil and sediment logging will be conducted in accordance with this SOP to ensure quality and consistency in field activities.

5.2. Field paperwork will be reviewed by office staff personnel and/or project manager to ensure completeness and accuracy in logging records.

6. References

6.1. None

END OF DOCUMENT

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification	
Use Wire Squares	4096	4,096,000	-20	Boulder	GRAVEL
	1024	1,024,000	-10		
	256	256,000	-8		
				Cobble	
	64	64,000	-6		
				Pebble	
	16	16,000	-4		
5	4	4,000	-2		
				Granule	
6	3.36	3,360	-1.75		
7	2.83	2,830	-1.50		
8	2.38	2,380	-1.25		
10	2.0	2,000	-1.00		
				Very Coarse Sand	SAND
12	1.68	1,680	-0.75		
14	1.41	1,410	-0.50		
16	1.19	1,190	-0.25		
18	1.00	1,000	0.00		
				Coarse Sand	
20	0.84	840	0.25		

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification
25	0.71	710	0.50	
30	0.59	590	0.75	
35	0.50	500	1.00	
				Medium Sand
40	0.42	420	1.25	
45	0.35	350	1.50	
50	0.30	300	1.75	
60	0.25	250	2.00	
				Fine Sand
70	0.210	210	2.25	
80	0.177	177	2.50	
100	0.149	149	2.75	
120	0.125	125	3.00	
				Very Fine Sand
140	0.105	105	3.25	
170	0.088	88	3.50	
200	0.074	74	3.75	

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification	
230					
	0.0625	62.5	4.00		
				Coarse Silt	MUD
270					
	0.053	53	4.25		
325					
	0.044	44	4.50		
Analyzed by Pipette or Hydrometer	0.037	37	4.75		
	0.031	31	5.0		
				Medium Silt	
	0.0156	15.6	6.0		
				Fine Silt	
	0.0078	7.8	7.0		
				Very Fine Silt	
	0.0039	3.9	8.0		
				Clay (Note: Some use 2: (or 9N) as the clay boundary.)	
	0.0020	2.0	9.0		
	0.00098	0.98	10.0		
	0.00049	0.49	11.0		
	0.00024	0.24	12.0		
	0.00012	0.12	13.0		

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification
	0.00006	0.06	14.0	

Table 2
Modified Burmister System Descriptors

Fractions		Proportion Descriptors		
(+)	Major Fraction	Quantity	Descriptor	Abbreviation
(-)	Minor Fraction	35% - 50%	and	a
e.g., a medium to coarse SAND which is predominantly medium grained would be written as: m(+) - c <u>SAND</u>		20% - 35%	some	s
		10% - 20%	little	l
		1% - 10%	trace	t

Modifiers:
(+) Upper a of the range
(-) Lower a of the range

Table 3
Plasticity of Sediment Samples

Material	Symbol	Feel	Ease of Rolling Thread	Minimum Thread Diameter	Plasticity Index	Plasticity
Clayey SILT	CyM	Rough	Difficult	1/4"	1 to 5	Slight (Sl)
SILT & CLAY	M & C	Rough	Less Difficult	1/8"	5 to 10	Low (L)
CLAY & SILT	C & M	Smooth, dull	Readily	1/16"	10 to 20	Medium (M)
Silty CLAY	MyC	"Shiny"	Easy	1/32"	20 to 40	High (H)
CLAY	C	Waxy, very shiny	Easy	1/64"	40 +	Very High (VH)

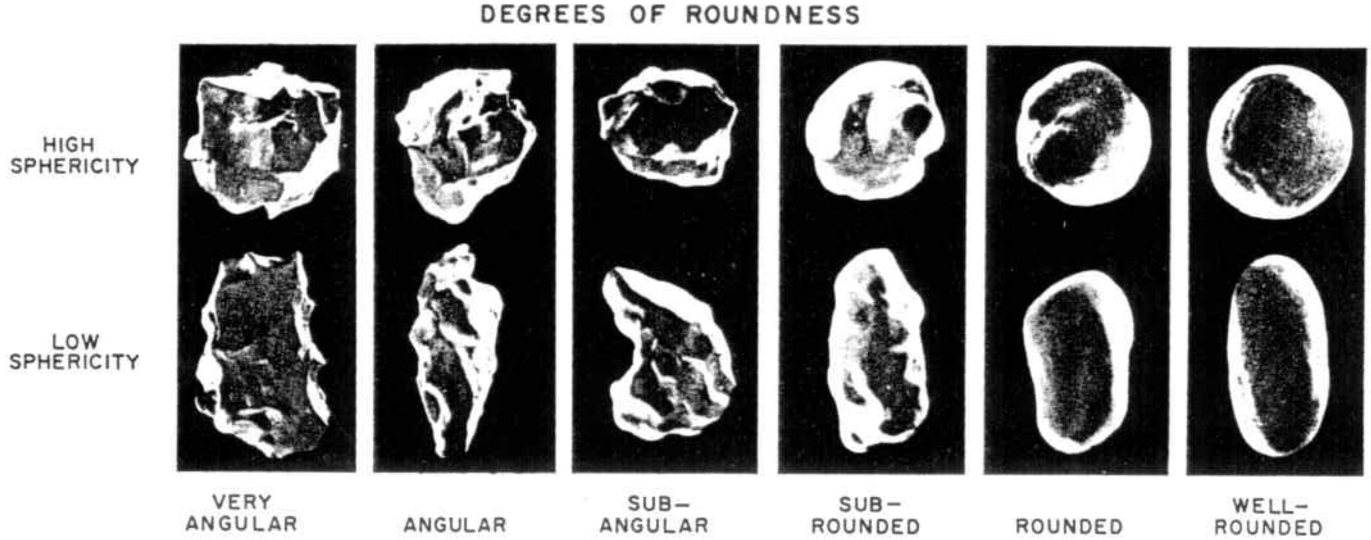
Table 4
Density and Cohesiveness of Sediment Samples

Density of Cohesionless Soils		Consistency of Cohesive Soils	
Blow Counts	Relative Density	Blow Counts	Consistency
0 to 4	Very Loose	0 to 2	Very Soft
5 to 9	Loose	2 to 4	Soft
10 to 29	Medium Dense	4 to 8	Medium
30 to 49	Dense	8 to 15	Stiff
50 to 79	Very Dense	15 to 30	Very Stiff
80 or more	Extremely Dense	30 or more	Hard

Table 5
Description of Sediment Properties

Sediment Parameter	Properties
Color	The color of the sample should be described for the wet sediments. If possible the color should be referenced to a standard color chart such as a Munsell7 Color Chart.
Primary Grain Size	Primary grain size refers to the size of the predominant sedimentary size class within the material (as judged visually). The grain size divisions should conform to the standard Wentworth Scale divisions, as shown in Table 1.
Secondary Grain Size(s)	Secondary grain size(s) refer to material which, as a grain-size group, comprises less than the majority of the sediment. Aside from stating the size classification, the relative percentage of the material must be stated. The grain size divisions should conform to the standard Wentworth Scale divisions as shown in Table 1. To describe the approximate percentage of the secondary grain size(s) present, qualifiers shown in Table 2 should be used.
Moisture Content	The moisture content of the sample should be described as dry, slightly moist, moist, or wet. Gradation from one state to another should be recorded as, for example, moist to wet, or moisty wet.
Sorting	The relative degree of sorting of the sediment should be indicated as poor, moderate, good, or very good. The degree of sorting is a function of the number of grain size classes present in the sample; the greater the number of classes present the poorer the sorting. In addition, for samples composed only of sand, the relative degree of sorting is a function of the number of sand-size subclasses present.
Sphericity	Sphericity is a measure of how well the individual grains, on average, approximate a sphere. The average sphericity of the sand and larger size fractions should be described as low, moderate or high. A chart illustrating various degrees of sphericity is presented in Figure 1.
Angularity	Angularity, or roundness, refers to the sharpness of the edges and corners of a grain (or the majority of the grains). Five degrees of angularity are shown in Figure 1: Angular (sharp edges and corners, little evidence of wear); Subangular (edges and corners rounded, faces untouched by wear); Subrounded (edges and corners rounded to smooth curves, original faces show some areas of wear); Rounded (edges and corners rounded to broad curves, original faces worn away); and, Well Rounded (no original edges, faces, or curves, no flat surfaces remain on grains).
Sedimentary Structures	Sedimentary structures are such things as varved layers, distinct bedding, or stratification.
Density -or- Cohesiveness	The density of cohesion of a sample (for the purposes of this application) refer to the sample's resistance to penetration by a sampling device. Density is used in reference to sediments primarily silt-size and coarser while cohesiveness is used in reference to primarily clay-sized sediments. Density or cohesiveness can be assessed from the number of blows from "standard" split-spoon sampling (i.e., 140# hammer, 30" fall, 2" X 2" (O.D., 1 3/8" I.D.)) split-spoon samplers according to the scale in Table 3.

FIGURE 1

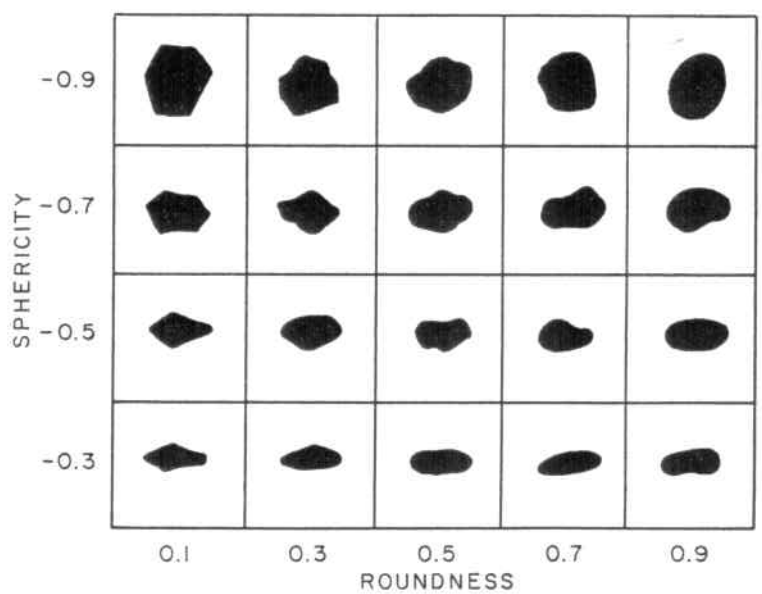


SPHERICITY

0.3 LOW
0.5 & 0.7 MODERATE
0.9 HIGH

ROUNDNESS

0.1 ANGULAR
0.3 SUBANGULAR
0.5 SUBROUNDED
0.7 ROUNDED
0.9 WELL ROUNDED



Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geoprobe® Screen Point Groundwater Sampling

SOP ID: 10024
Date Initiated: 11/21/96
Revision No. 002: 02/28/02

Approved By:	***/s/ David C. Brisson***	***02/21/02***
	David C. Brisson	**Date**
	Project Geologist	
	/s/ Nick D. Skoularikis	***02/21/02***
	Nick D. Skoularikis	**Date**
	Director of Quality	

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial issue	11/21/96	
001	06/17/97	No record.
002	02/28/02	Modified to conform with new SOP format; updated Geoprobe equipment list and procedure to include SP 15 Sampler, added references.

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geoprobe® Screen Point Groundwater Sampling

1. Purpose and Scope

This standard operating procedure (SOP) has been prepared to describe the methods and procedures to be used to collect groundwater samples using the Geoprobe® Screen Point Groundwater Sampling device.

The techniques and procedures are adapted from the Geoprobe Systems Technical Bulletin 94-440, dated April 1994. Techniques and procedures associated with operation of the Geoprobe® and the collection of soil samples using Geoprobe® methodologies are presented in the SOP ID 10011 entitled, *Standard Operating Procedures for Geoprobe® Probing and Sampling*.

2. Definitions

2.1. **Geoprobe®[1]:** A vehicle-mounted, hydraulically-powered, soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples.

Screenpoint Groundwater Sampler®: A stainless steel, completely sealed groundwater sampler installed using the Geoprobe® to collect representative groundwater samples from unconsolidated formations.

3. Equipment

The following equipment is required to collect samples of groundwater using the Geoprobe® Screen Point Sampling Methodologies.

Screen Point and SP15 Sampler Parts	Part Number
Groundwater Sampler Drive Head	GW-430B
O-Ring for Groundwater Sampler Drive Head	GW-430R
Screen Point Sampler Sheath	GW-440
Drive Point Seat	GW-440-1

1 Geoprobe is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.

O-Ring for Drive Point Seat	GW-440-1R
Screen Sleeve	GW-441
Screen Connector with PRT-Adapter Threads	GW-443
O-Ring for Screen Connector	GW-443R
Screen Insert and Plug (Assembled Unit)	GW-444
O-Ring for Screen Plug	GW-444R
SP15 Stainless Steel Screen	GW1520
SP15 Sampler Sheath	GW1510
GW Drive Head	GW1515
Screen Push Adapter	GW1535
Expendable Drive Point	GW-1555
O-Ring for Drive Point	GW-445R
Screen Connector Pin	GW-446
Screen Connector Pin Punch	GW-447

Geoprobe® Tools	Part Number
Probe Rod (4 Foot)	AT-104B
Probe Rod (3 Foot)	AT-10B
Probe Rod (2 Foot)	AT-105B
Probe Rod (1 Foot)	AT-106B
Drive Cap	AT-11B
Pull Cap	AT-12B
Extension Rod	AT-67
Extension Rod Coupler	AT-68
Extension Rod Handle	AT-69

Optional Equipment	Part Number
Tubing Bottom Check Valve	GW-42
Check Balls for Check Valve	GW-42-1
Polyethylene Tubing, 1/4" ID	TB-251
Probe Rod Pull Plate	AT-122
PRT Fitting	PR-25S or PR-30S

4. Procedures

Procedures referred to in this section refer specifically to those Geoprobe® operations associated with the use of the screen point sampler. All other Geoprobe® operations are described in the Loureiro Engineering Associates, Inc. (LEA) SOP ID 10011 entitled, *Standard Operating Procedures for Geoprobe® Probing and Sampling*.

4.1. Utilities Clearance

4.1.1. Notify the appropriate "one call" utility notification service (e.g., in Connecticut, Call Before You Dig at 1-800-922-4455) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification. The Project Engineer/Manager **must** call and confirm that each utility has been to the site and has marked their respective lines.

4.1.2. On private sites, consult with the owner or other person knowledgeable about the site as to the locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the Project Engineer/Manager, a pipe locator can also be used to assist in locating utilities.

4.1.3. Note that OSHA may have additional requirements for the location of utilities.

4.1.4. All efforts to locate underground utilities (including names of owner or designee and time) should be properly documented in the field logbook or field paperwork prior to onset of the work scheduled.

4.2. Health and Safety

4.2.1. The foreman or supervisor of the drilling crew shall be the competent person as required by OSHA for all of their work. However, this does not relieve any other LEA representative from bringing to his or her attention conditions which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site. The LEA representative is responsible for ensuring that LEA activities are conducted in accordance with the site-specific Health and Safety Plan.

4.3. Site Preparation

4.3.1. A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".

4.3.2. An equipment decontamination area shall be assembled as described in Section 4.14 within the exclusion zone.

4.3.3. All personal protective equipment as required in the site-specific health and safety plan shall be donned.

4.4. Basic Operation

4.4.1. The outer appearance of the Screen Point Groundwater Sampler, once it has been assembled properly, looks just like a normal Geoprobe® 3-foot probe rod. The fully assembled Screen Point SP15 Sampler has a slightly larger diameter than the probe rods and is 51 inches in length and 1.5 inches in diameter. The bottom of both the Screen Point Sampler and Screen Point SP15 Sampler are fitted with an expendable drive point, while the top of the sampler can be connected to Geoprobe® rods and other accessories. The assembled sampler can be driven either hydraulically by any Geoprobe® Model 5400 machine, manually using drilling machines, or by using cone penetrometers.

4.4.2. At sampling depth the probe rods attached to the sampler are retracted two feet to allow the sampler screen to be pushed out into the formation.

4.5. Assembly

4.5.1. Screen Point Sampler

4.5.1.1. Push the screen insert and plug (GW-444) equipped with an O-ring (GW-444R) into the screen sleeve (GW-441) which is the end of the screen sleeve with only one drain hole.

4.5.1.2. Push the screen connector (GW-443), which is fitted with an O-ring (GW-443R) over the top of the screen sleeve and secure with the connector pin (GW-446). The pin can easily fall out since it is a rather loose fit.

4.5.1.3. Insert the screen connector end of the assembled screen halfway into the screen point sampler sheath (GW-440) from either end. Again, the screen connector end is inserted first.

4.5.1.4. Slide the drive point seat (O-ring GW-440-1R) over the protruding end of the screen sleeve and screw it tightly into the sampler sheath.

4.5.1.5. Push the screen sleeve up into the sampler sheath just far enough to fit the expendable drive point (O-ring GW-445R) into the bottom end of the drive point seat.

4.5.1.6. Screw the O-ring end of the water sampler drive head (GW-430B) into the top of the sampler sheath. Make sure all threads are fastened tightly.

4.5.2. Screen Point 15 Sampler

4.5.2.1. Install O-ring (GW1555R) on an expendable point (GW1555) and firmly seat the point in the necked end of sampler sheath (GW1510).

4.5.2.2. Place a grout plug (GW 1550, GW 1551) in the lower end of a stainless steel (or PVC) screen (GW 1520, GW 1530).

4.5.2.3. When using a stainless steel screen, install another O-ring in the groove on the upper end of the screen. Slide the screen inside the sampler sheath with the grout plug to the bottom of the sampler.

4.5.2.4. Install another O-ring on the bottom of the drive head and thread the drive head onto the sampler sheath.

4.6. Probing

4.6.1. Drive the water sampler approximately two feet below the depth level where you want to sample by attaching it to the Geoprobe® rods.

4.6.2. Never drive the water sampler without the O-ring (GW-445R) attached to the drive point. Failure to use this O-ring may result in flowing soils clogging the screen during driving.

4.7. Screen Deployment

Once the screen point sampler has been driven to the base of the interval desired for sampling, the probe rods are retracted a distance of two feet and the screen is pushed out into the formation. The following procedures should be used:

4.7.1. Retract the probe rods from the ground a distance of two feet.

4.7.2. Insert Geoprobe® stainless steel extension rods (AT-67) down the bore of the probe rods, with a screen push adapter (GW1535) on the end of the extension rod (this adapter is useful, but not required to perform this task). An extension rod coupler (AT-68) must be placed at the bottom end of the lead extension rod in order to protect the threads at the end of this rod, should a screen push adapter not be used. One extension rod will be required for each probe rod in the ground, plus one extension rod for the screen point sampler itself. Place an extension rod handle (AT-69) at the top of the extension rod string.

4.7.3. For the Screen Point Sampler, when the proper number of extension rods have been coupled together and inserted down the bore of the probe rods, the last extension rod will protrude from the top of the probe rods a distance of approximately 24 inches.

4.7.4. Pushing down on the extension rods should now push the screen out into the formation. When the screen is completely pushed out, the extension rod handle will come to rest at a final position approximately 3 inches above the top of the probe rods.

4.7.5. In extreme situations, it may be necessary to tap on the top of the extension rod handle with a hammer in order to force the screen out into the formation.

4.7.6. For the SP15 Sampler, the extension rods are lowered down the inside of the probe rods until contacting the bottom of the sampler screen. The probe rods and sampler sheath are retracted about 44 inches while holding the screen in place with the extension rods. When all of the extension rods have been extracted, a groundwater sample can be collected.

4.8. General Sampling Considerations

4.8.1. There are two methods for obtaining a sample from the GW-440 series screen point sampler or SP15 Sampler. Groundwater samples can be obtained by bailing or pumping directly from the bore of the probe rods above the screen point. Alternatively, a tubing system may be attached directly to the top of the deployed screen and samples pumped to the surface using either a peristaltic pump or other means of vacuum lift.

4.9. Bottom Check Valve Sampling

4.9.1. One type of groundwater sampling method that can be employed is to pump directly from the bore of the probe rods immediately above the screen point (both GW-440 series and SP15 Sampler) using a tubing bottom check valve. This method is often referred to as "sampling from the open rods," and is essentially the same for bottom check valve sampling as it is for bailing. Note that in order for this method to be employed, the piezometric head in the saturated formation must be above the top of the deployed screen point; water from the formation must rise into the probe rods where it can then be pumped to the surface. Sampling is performed as described in the following steps.

4.9.1.1. Either 3/8-inch OD Teflon® (TB-30T) or polyethylene (TB-25L) tubing may be used for groundwater sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation.

4.9.1.2. Place a tubing check valve (GW-42) at the bottom end of a roll of tubing. This bottom check valve will fit either of the tubing types listed above.

4.9.1.3. Push the tubing, check valve end first, down the bore of the probe rods until it strikes the top of the screen point sampler.

4.9.1.4. Lift the tubing approximately 4 inches off the bottom (top of the screen point sampler) and oscillate the tubing up and down in 8-inch to 12-inch strokes. In field practice, the tubing is oscillated up and down by hand at a rate of 60 to 100 strokes per minute. This pumping can yield as much as 500 milliliters of sample per minute.

4.9.1.5. Air bubbles appearing in the pumped stream indicate that the pumping action is exceeding recharge from the screen point, allowing air to enter at the check valve end. For most purposes, intermixing of air with the pumped sample is undesirable. The pumping rate should be slowed and balanced with the recharge rate.

4.9.1.6. If water cannot be pumped to the surface, sufficient sample may be obtained by using the tubing and check valve as a bailer. Oscillate the tubing to fill it with several feet of sample and then remove the tubing from the rods.

4.10. Sampling Through PRT Tubing

4.10.1. "PRT" (post run tubing) refers to a Geoprobe® proprietary system of tubing and fittings that are used both for vapor and groundwater sampling. This tubing is inserted down the rods after the sampler has already been driven to depth and has been deployed for sampling. The top of the screen point sampler is equipped with a PRT fitting, which serves as a receptacle for a corresponding PRT adapter fitted onto the end of the sampling tube.

4.10.2. In practice, the tubing with the PRT adapter at the lower end is inserted down the bore of the probe rods and screwed into the receptacle on the top of the sampler screen. This procedure forms a vacuum-tight sample train from the sampler screen to the ground surface. Sample is normally pumped to the surface using a peristaltic pump or other vacuum source.

4.10.3. The advantage of this method is that the sample is only placed in contact with the stainless steel sampler screen and tubing. The sample is never exposed to a free surface. The disadvantage of this method is that it is limited to maximum groundwater depths of 20 to 28 feet below ground surface.

4.10.4. The following procedures are used to obtain groundwater samples using PRT fittings and tubing.

4.10.4.1. Either 3/8-inch OD Teflon® (TB-30T) or polyethylene (TB-25L) tubing may be used for groundwater sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation. Each of these tubings has a corresponding PRT adapter that is required for this sampling. These adapters are shown in the following table:

Tubing and PRT Adapters

Tubing	Description	PRT Adapter Part Number
TB-30T	3/8-inch Teflon®	PR-30S
TB-25L	3/8-inch Polyethylene	PR-25S

4.10.4.2. Place the barbed end of the appropriate adapter into the selected tubing.

4.10.4.3. Push the adapter end of the tubing down the bore of the probe rods until it comes into contact with the PRT threads at the top of the screen point sampler.

4.10.4.4. Rotate the tubing counter-clockwise at the surface to screw the adapter into the screen point threads. Rotate the tubing several revolutions until the downhole adapter is completely seated and the tubing starts twisting. In this condition, the tubing will rotate backwards (clockwise) when released.

4.10.4.5. The tubing can now be attached to a peristaltic pump or vacuum source at the surface.

4.10.4.6. After sampling is complete, tubing should be removed by pulling it up at the surface. This will pull the tubing off the barbed end of the tubing adapter and will allow the operator to examine the connection at the top end of the screen point when it is pulled from the ground.

4.10.4.7. For the SP15 Sampler, a peristaltic pump can be used to collect groundwater samples (if the static water level is less than 25 feet). The 3/8 inch OD polyethylene tubing can be lowered through the probe rods and to the bottom of the SP15 Sampler screen, and connected to a peristaltic pump at the surface.

4.11. Sampler Removal and Retrieval

4.11.1. Remove all sampling tubes from the bore of the probe rods.

4.11.2. Pull all rods from the ground using the Geoprobe® machine. Care should be taken not to push down on the probe rods during removal.

4.11.3. Care should be taken to lift the screen point sampler vertically upward at the surface. Pulling the probe rods or sampler from the ground at any direction other than vertical may result in bending of the screen point sampler.

4.11.4. Dismantle the sampler at the surface and examine it for damage. Decontaminate all parts, replace all O-rings, and re-assemble the sampler for the next sample.

4.12. Sample Handling

4.12.1. All groundwater samples collected by the methods and procedures presented above will be treated exactly as any other groundwater sample. The sample will be handled in general accordance with the procedures and guidelines described in the LEA SOP ID 10004 entitled *Standard Operating Procedure for Liquid Sample Collection and Field Analysis*. However, because of the nature of the screen point sampling method, it is not necessary to attempt to "purge" a screen point sampler or to attempt to stabilize the field parameters prior to collecting the sample.

4.13. Equipment Decontamination

4.13.1. All sampling equipment used to collect groundwater samples must be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon knowledge of the site-specific contaminants and outlined in the site-specific work plan.

4.13.2. For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

4.13.2.1. Prior to commencing any field activities, the following solutions (as appropriate for the anticipated contaminants) will be prepared and placed into 500-ml laboratory squirt bottles: methanol (<10% solution) in water; 10% nitric acid; 100% n-Hexane; distilled, de-ionized (DI) water.

4.13.2.2. In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

4.13.2.3. Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The edges of the sheeting should be bermed to contain spills.

4.13.2.4. The order for decontaminating equipment is as follows:

1) Detergent Scrub
2) De-ionized (DI) Water Rinse
3) Hexane Rinse (to be used only if separate-phase petroleum product, other than gasoline, is present)
4) DI Water Rinse
5) 10 percent Nitric Acid Rinse (to be used only when metals are suspected as potential contaminants)
6) DI Water Rinse
7) Methanol (less than 10 percent solution) Rinse
8) Air Dry

4.13.2.5. Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

4.13.2.6. At the end of the project day, all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment will be disposed of in accordance with all applicable municipal, state, and federal regulations.

5. Quality Assurance/Quality Control

5.1. Quality assurance/quality control (QA/QC) procedures shall comply with those procedures described in Section 4. QA/QC samples, if required, (including performance evaluation samples, equipment blank samples, trip blank samples, and field duplicate samples) shall be collected according to the project-specific work plan.

6. References

6.1. Geoprobe® Systems, 1997, "1998-1999 Tools and Equipment Catalog".

6.2. Geoprobe® Screen Point 15 Groundwater Sampler Standard Operating Procedure, Technical Bulletin No. 95-1500.

6.3. Geoprobe® Screen Point Groundwater Sampler Standard Operating Procedure, Technical Bulletin No. 94-440.

END OF DOCUMENT

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Installing and Developing Monitoring Wells and Piezometers

SOP ID: 10007
Date Initiated: 02/20/90
Revision No. 006: 08/12/02

Approved By: ______________________ 8/12/02
Joseph T. Trzaski **Date**
Senior Scientist

______________________ 08/12/02
Nick D. Skoularikis **Date**
Director of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	02/20/90	
001-004	-	No record.
005	12/31/01	Formatting and minor revisions throughout.
006	08/12/02	Added section on utility clearance.

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Installing and Developing
Monitoring Wells and Piezometers

1. Purpose and Scope

This standard operating procedure (SOP) is designed to describe the methods and procedures used to install and develop monitoring wells and piezometers in a water-table aquifer. Monitoring well and piezometer installation and development shall generally follow the guidelines presented in the "*Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*" (United States Environmental Protection Agency (EPA), 1989), the "*RCRA Ground Water Monitoring Technical Enforcement Guidance Document*" (EPA, 1986), and any state or local guidance, or regulatory documents which are available.

This SOP describes general procedures and guidelines to be followed or consulted for the proper methods to be used when installing monitoring wells or piezometers in unconsolidated deposits and bedrock. Because each site is unique and the purpose of the monitoring wells may vary from installation to installation, no definitive rules can be established. Throughout this SOP reference to monitoring wells is also intended to mean piezometers unless specifically indicated otherwise. This SOP also applies to monitoring wells and piezometers installed by Geoprobe® direct push technologies.

2. Definitions

Geoprobe® Direct Push Machine: A vehicle-mounted, hydraulically-powered machine that uses static force and percussion to advance small-diameter sampling tools into the subsurface for collecting soil, vapor , or groundwater samples. Geoprobe® machines ad tools are manufactured by Geoprobe Systems®, Salina, Kansas.

Prepacked Well Screen (0.5 in and 1.5 in): An assembly consisting of a clotted polyvinyl chloride (PVC) pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.5 inch Schedule 80 PVC pipe with 0.01 in slots. (Alternatively, a 1.5 inch Schedule 80 PVC pipe can be used). Stainless steel wire mesh with a pore size of 0.011 in makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe®

prepacked screens are available in sections of various lengts (3 ft or 5 ft)and a nominal inside diameter of 0.5 in or 1.5 in.

3. Equipment and Decontamination

3.1. Equipment Supplied by the Drilling Contractor:

- Drilling rig.
- Monitoring well casing.
- Monitoring well screen.
- Bottom caps, plugs or points.
- Centering guides (if they are to be used).
- Filter pack sand.
- Bentonite.
- Cement-bentonite grout.
- Mud-scale to measure densities.
- Protective casing or road box.
- Steam-cleaning apparatus and supplies.
- Suitable containers (e.g., Department of Transportation (DOT)-approved 55-gallon drums with liners) for soil cuttings, well development water, and water generated from steam cleaning.
- Metal stamps for permanently marking wells.
- All necessary permits and licenses.
- If the Geoprobe® is used for well installation, Geoprobe®-specific equipment for well installation.

3.2. Equipment Supplied by Loureiro Engineering Associates, Inc. (LEA)

- Field forms.
- Indelible markers.
- Lock(s) and keys.
- Well development equipment (pumps, surge block, bailers, etc.).
- Analytical instrumentation (Analytical instrumentation includes, but is not necessarily limited to turbidity meters, pH meters, specific conductivity meters, and thermometers.).
- Calibration supplies for all analytical instrumentation, as appropriate.
- Alconox®, or other non-phosphate laboratory grade detergent.
- 5-gallon buckets.
- Decontamination brushes.
- Distilled, de-ionized water.
- Decontamination fluids (<10% methanol in water, 100% n-hexane, and

10% nitric acid).

3.3. Equipment Selection and Specifications

The following specifications will be followed:

Cement-Bentonite Grout: If cement-bentonite is utilized, the cement-bentonite grout will be a mixture of 95 pounds of Type II Portland cement, 4 to 6 pounds of powdered sodium bentonite, and 5 gallons of potable water. The bentonite must be thoroughly mixed with the water before the cement is added. The cement bentonite grout shall have a density of 14 pounds/gallon.

Filter Pack Sand: All filter pack sand will be clean, well-rounded silica sand, in factory-sealed bags. The sand will conform to the most recent version of the American Water Works Association (AWWA) Standard AWWA/ANSI A100 for water wells. In brief, the standard states that filter pack sand will have an average specific gravity of 2.5 with not more than 1% of the material having a specific gravity less than 2.25. Thin, flat or elongated particles shall not exceed 2% of the material, no more than 5% of the material shall be soluble in hydrochloric acid, and the material shall be washed and free of shale, mica, clay, dirt, loam, and organic impurities.

Bentonite: All bentonite will be pure, additive-free bentonite whether it is pellets, chips, or powder.

3.4. Equipment Decontamination

3.4.1. Equipment Decontamination for Monitoring Well Installation

All well materials and drilling equipment which are used to construct a monitoring well or piezometer must be clean and free of any potential contaminants. All well construction materials not certified by LEA personnel as decontaminated when delivered will be decontaminated by steam cleaning before being installed. Drilling equipment must also be decontaminated, prior to beginning work, by steam cleaning. Geoprobe® equipment shall be cleaned using a detergent such as Liquinox®.

All decontamination activities shall be completed at a specially constructed decontamination pad (or a portable decontamination unit). The decontamination pad shall be constructed before any drilling activity begins. The pad shall be constructed of high-density polyethylene (HDPE) liner material, of sufficient size and strength to allow the drill rig access to the pad, and bermed to contain the generated wastewaters.

3.4.2. Equipment Decontamination for Sampling Equipment and Well Development.

All materials and equipment used to sample soil or which enter a well must be clean and free of any potential contaminants. In general, the choice of decontamination procedures shall be based upon the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below shall be followed.

3.4.2.1. Prior to commencing any field activities, the following solutions (as appropriate for the anticipated contaminants) shall be prepared and placed into 500-ml laboratory squirt bottles: <10% methanol in water; 10% nitric acid in water; 100% n-hexane; distilled, de-ionized water. Other chemicals may be used for decontamination of site-specific contaminants if needed for decontamination of those contaminants.

3.4.2.2. In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

3.4.2.3. Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting shall be of sufficient size to contain any accidental discharge of decontamination solutions. The plastic shall be bermed to contain spills. The decontamination for Geoprobe® equipment shall be performed in buckets or in tubs.

3.4.2.4. The order for decontaminating equipment is as follows:

1) Detergent scrub.
2) De-ionized (DI) water rinse.
3) Hexane rinse (to be used only if separate-phase petroleum product, other than gasoline, is present).
4) DI water rinse.

5) 10% nitric acid rinse (to be used only when metals are suspected as potential contaminants).
6) DI water rinse.
7) Methanol rinse (<10% solution).
8) Air dry.

The order of decontamination may change if different chemicals are used.

3.4.2.5. Disposable materials such as cord shall not be decontaminated and shall be disposed of after use.

3.4.3. At the end of the project day, all spent decontamination fluids and materials, such as the polyethylene sheeting and personal protective equipment, shall be managed and/or disposed of in accordance with all applicable municipal, state, and federal regulations.

4. Procedures

4.1. Utilities

4.1.1. Notify the appropriate "one call" utility notification service (e.g. Call Before You Dig at 1-800-922-4455, Contractor ID: 10502) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification. The Project Engineer/Manager **must** call and confirm that each utility has been to the site and has marked their respective lines.

4.1.2. On private sites, consult with the Owner or other person knowledgeable about the site as to the locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the Project Engineer/Manager, a pipe locator can also be used to assist in locating utilities.

4.1.3. Note that OSHA may have additional requirements for location of utilities.

4.1.4. All efforts to locate underground utilities (including names of owner or designee and time) should be properly documented in the field logbook prior to onset of the work scheduled.

4.2. OSHA

4.2.1. The Senior LEA representative shall be the Competent Person required by OSHA for all work. However, this does not relieve other LEA representatives from bringing to his or her attention conditions, which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site.

4.3. Monitoring Well and Piezometer Installation

The specific monitoring well installation methodologies are dependent upon the specific drilling method used. In general, monitoring wells will be constructed through the inside of the drill stem, once the borehole has been advanced to the desired depth. For Geoprobe® monitoring wells, the wells will be constructed through the inside of stainless steel casing.

4.3.1. Borehole Advancement

If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole must be backfilled with bentonite pellets, bentonite chips, or a bentonite-cement slurry to a depth of approximately one foot below the intended well depth. Approximately one foot of clean sand must be placed on top of the backfill to return the borehole to the proper depth for the well installation.

For bedrock monitoring wells, the borehole shall be advanced to approximately one foot into competent bedrock and the isolation casing grouted into place. The grout is to be allowed to cure for at least 24 hours before drilling continues. After the grout has cured, the borehole is to be advanced using the appropriate technique (e.g., coring, air rotary, mud rotary) to the desired depth. If the borehole is advanced to a depth greater than that at which the well is to be set, the borehole shall be backfilled as described above.

For Geoprobe® installed wells and piezometers, the steel casing will be drilled to the specified depth of the bottom of the well using the Geoprobe® and in certain cases manually.

4.3.2. Installation of Well Screen and Casing

The appropriate lengths of well screen (with bottom cap, or plug, or well point) and casing must be joined watertight and carefully lowered inside the drill stem to the bottom of the borehole. If centering guides are used, they must be placed at intervals around the well casing, beginning no lower than 5 feet above the top of the screen.

4.3.3. Design and Installation of the Filter Pack

After the well screen and casing are installed in the borehole, the filter pack shall be installed. For monitoring wells in unconsolidated materials, the selection of the appropriate filter pack material shall be based upon a grain-size analysis of a sample collected from the intended screen interval. The selection of the appropriate filter pack material shall be based upon the methodologies presented in the "*Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*" (EPA, 1989), the "*RCRA Ground Water Monitoring Technical Enforcement Guidance Document*" (EPA, 1986), or any state or local guidance, or regulatory documents which are available. In the absence of grain size analyses, the filter pack material shall be selected based upon an experienced geologist's best judgment as to the appropriate material.

For bedrock monitoring wells, the well screen and filter pack are emplaced primarily to stabilize the borehole and are therefore not sized in the same manner as for a monitoring well in unconsolidated sediments. For typical bedrock monitoring wells, 10-slot well screen is appropriate. The selection of the appropriate filter pack material shall be based upon the slot size selected for the well screen.

A filter pack of clean silica sand will be placed around the well screen. Place the filter pack into the borehole at a uniform rate in a manner that will allow even placement of the sand. The drill stem shall be raised slowly while the sand is being placed to avoid caving of the borehole walls; the drill stem shall never be raised above the top of the filter pack during installation. Using a stainless steel weight on the end of a fiberglass tape, continuously sound the top of the filter pack as it is being installed. The filter pack shall extend from a depth of approximately one foot below the screened interval to a minimum height of one to two feet above the top of the well screen. However, this length may be adjusted if it would create the potential for cross-contamination or in the case of shallow water tables.

A finer-grained sand cap shall be installed for a minimum of one foot above the filter pack. This height may also be adjusted in the case of shallow water tables.

4.3.4. Installation of Impermeable Seal

An impermeable seal at least two feet thick must be placed on top of the fine sand cap. The seal may be composed of either bentonite pellets or a bentonite slurry. The pellets must be placed into the borehole in a slow and continuous manner that prevents bridging. This is especially important in deeper monitoring wells where the pellets may have to be emplaced through a considerable depth of standing water in the borehole.

The bentonite slurry shall be prepared by mixing approximately 15 pounds of bentonite powder with 7 gallons of water for each one cubic foot of slurry needed. The slurry shall be emplaced in the borehole via a tremie pipe. The tremie pipe must be plugged on the bottom and have openings along the sides of the bottom one foot of pipe. This will allow the slurry to be emplaced into the borehole without disturbing the fine sand cap. This procedure is especially important for the relatively deeper wells.

Verify the position of the top of the bentonite seal using a weighted tape measure. If all or a portion of the bentonite seal must be emplaced above the water table, hydrate the bentonite with clean water. Allow 30 minutes after adding the water for the bentonite to hydrate.

The thickness of the bentonite seal may be adjusted for wells completed in aquifers with shallow water tables.

4.3.5. Installation of Grout Backfill

Place an annular seal of cement-bentonite grout above the bentonite seal. Install the cement-bentonite grout continuously from the bottom of the annular space to the ground surface through a tremie pipe. The tremie pipe must be plugged on the bottom and have openings along the sides of the bottom one-foot length of pipe. This will allow the grout to be emplaced into the borehole without disturbing the bentonite seal. Alternatively, a bentonite slurry can be used.

4.3.6. Surface Completion

All monitoring wells will be finished at the surface with a concrete pad (Figure 1). The concrete pad shall typically be two-feet square and at least four inches thick. The concrete shall fill the borehole to a depth below the frost line. The pad shall be constructed in one continuous pour of concrete. Note that some of the cement-bentonite grout used for the annular seal may have to be removed to install the concrete pad. A survey pin may be installed in the concrete pad before it dries, if necessary.

For monitoring wells that will be completed above-grade, a locking steel protective casing shall be installed in the concrete. The protective casing shall extend at least three feet into the ground and two feet above ground. For monitoring wells that will be completed flush, a steel roadbox, suitable for traffic loads, with a gasketed cover and drain shall be installed.

Each well will be properly labeled on the exterior of the locking cap or protective steel casing with a metal stamp indicating the permanent well identifier.

4.3.7. Well Protection Bollards

Guard posts may be installed in high-traffic areas for additional protection. One to four guard posts would be installed around the protective casing, within the edges of the concrete pad. If used, guard posts will consist of concrete-filled steel tubes, at least 3 inches in diameter, painted with multiple coats of epoxy-based paint to prevent rust. The guard posts would extend at least two feet below ground and approximately three feet above ground.

4.3.8. Geoprobe® Prepacked Screen Monitoring Well Installation

The installation of prepacked screen monitoring wells in general follows the following four steps (Figure 2):

4.3.8.1. Anchoring the Well Assembly at Depth

In the first step, an expendable anchor point is driven to the desired depth on the end of a 2.125 outside diameter probe rod string. A prepacked screen assembly is inserted into the inside diameter of the rod string with 5-ft sections of PVC riser. The screens and riser pipe are attached to the anchor point via a snap-lock connector. If the monitoring well is to have a flush-mount finish, it is suggested to prepare a large enough hole to accept a standard well protector before driving the probe rods.

4.3.8.2. Providing a Sand Pack and Grout Barrier

The natural formation will sometimes collapse around the well screens as the probe rod string is withdrawn. This is frequently encountered in sandy formations below the water table. This provides an effective barrier between the screens and grout material used to seal the well annulus. If the formation does not collapse, a sand barrier must be placed from the surface while retracting the well casing. This procedure needs to be followed carefully to prevent the grout from reaching the well screens, potentially giving rise to non-representative samples.

Using a flat tape measure or water level sounder, determine the depth from the top of the PVC riser to the bottom of the annulus between the riser and probe rods. If unstable conditions have resulted in formation collapse (measured depth of 2 to 3 ft), then proceed to 4.3.8.3. if the borehole has not collapsed, then retract the casing to 1 ft above the screen while adding sand. Take measurements with a weighted tape. Continue until 2 ft of sandpack have been established above the well screen.

4.3.8.3. Installing a Bentonite Seal above the Screen

Proceed as in section 4.3.4. above. Bring the bentonite seal to within 2 ft from ground surface to allow well completion

4.3.8.4. Installing Well Protection.

Proceed as in Section 4.3.6. above.

5. Well Development

Monitoring well development may be accomplished by surging and bailing (or pumping), or over pumping. Other methods, such as air jetting, backwashing, or air-lift pumping, shall be avoided because these methods introduce fluids into the formation and may have unexpected influences on groundwater quality, if only for a short period of time.

Immediately upon opening the well, the air in the wellhead will be sampled for VOCs using a portable VOC analyzer, such as a Photovac MicroTIP®. The well cap shall be opened slightly and the sampling port of the VOC analyzer shall be inserted into the well. The maximum reading shall be recorded on the appropriate field paperwork. The instrument shall be zeroed with ambient air prior to the measurement, and the initial and final readings shall be recorded for each well.

Measures shall be taken during well sampling to prevent surface soils from coming in contact with the purging equipment and lines. Typically, a polyethylene sheet is placed on the ground providing adequate coverage for the equipment being used.

In addition, the procedures described in LEA SOP ID 10004 in the sections for Field Analysis, Well Evacuation, and Sample Withdrawal shall be followed.

5.1. Surging and Bailing

In surging and bailing, a well is developed by alternately surging a short section of the screen with a tight-fitting surge block. Begin by lowering the surge block to the top of the screened interval and swab the well with a pumping action with a typical stroke of 2 to 3 feet. (Begin surging at the top of the well intake to avoid having loosened material from "sand-locking" the surge block.) Do not surge the well too violently to avoid damaging the well screen or the filter pack. Remove the surge block at regular intervals and bail (or pump) the fine material from the well. Proceed with surging throughout the length of the well screen, being careful to avoid hitting the bottom of the well. Check the quality of the bailed water at regular intervals, as described in Section 5.3.

In cases where a considerable volume of sediment may initially be drawn into the well, begin surging the well gently in the casing above the well screen. Proceed with surging and bailing to the bottom of the screened interval.

5.2. Overpumping

In overpumping, a well is developed by operating a pump in the well at a capacity which greatly exceeds the formation's ability to supply water. The flow velocity into the well during overpumping usually greatly exceeds the flow velocity induced during normal sampling. This increased velocity causes movement of particles from the formation into the well.

Begin developing the well by installing a suitable pump at the bottom of the well. Alternatively, a surface-mounted pump with a suction hose may be used if the drawdown inside the well will not exceed the pump's available lift. The discharge from the pump shall be directed to approved containers. The pump (or intake hose) must be equipped with a backflow-prevention valve to prevent introducing aerated water into the aquifer.

Start the pump and discharge water at the highest practical rate. If the well runs dry, stop the pump and allow the well to recharge. Check the quality of the discharged water at regular intervals as described in Section 4.3.

5.3. Completing Well Development

During bailing or pumping, measure and record water quality parameters to gauge the degree and effectiveness of development. Typically, pH, temperature, specific conductivity, and turbidity shall be checked at periodic intervals (but at least every three well-volumes) until the purge water begins to appear clear. Then measurements shall be made after each well volume until the parameters stabilize. The water quality parameters may be considered stable when:

- pH, temperature, and specific conductivity of consecutive measurements have relative percent differences (RPD), as defined below, of less than 10%; and,
- The turbidity is 5 NTU or less (applicable only in aquifers with low percentages of fines. This may not be achievable in all situations, but the turbidity shall be less than 50 NTU and shall stabilize with an RPD of less than 10%).

However, in no case shall the development stop before the above criteria are met, and:

- At least 3 well volumes have been removed; or,
- The well has been surged and pumped for at least 30 minutes.

The RPD between two measurements (e.g., M1 and M2) is calculated as follows:

$$RPD = \frac{|M1 - M2|}{(M1 + M2)/2} \times 100\%$$

All well development equipment and supplies shall be thoroughly decontaminated prior to and between each monitoring well. Place all development water into properly labeled, suitable containers; leave all filled containers in an appropriate location.

6. Documentation

6.1. Well Development

Well development activities will be documented on the appropriate field forms, and specifically on the "Field Data Record Groundwater" and "Well Development Report" forms. Information provided on those forms includes: purge method, amount of water per well volume, instrument readings after purging of each well volume.

6.2. Monitoring Well Completion Log Forms

During the installation of a monitoring well, complete records must be kept of quantities and types of all well construction materials used.

A complete geologic log shall be kept during advancement of the borehole for the well. The procedures for completing geologic logs are presented in *Standard Operating Procedure for Geologic Logging of Unconsolidated Sedimentary Materials* (SOP ID 10015). However, the additional information pertinent to monitoring well installations shall be recorded on a separate form. A monitoring well completion form is provided in Attachment 1. In addition typical wellhead details – one for flush-mount well completions and one for above-grade completions - are provided as Figure 1. Whenever a monitoring well is installed, record all appropriate information concerning the quantity of materials used, the type and manufacturer of the materials, the mixtures of grouts or slurries, and any pertinent notes regarding the installation of each well.

After the project is completed, submit a copy of the attached Geologic Soil Boring/Well Completion Log Request Form along with copies of all Monitoring Well Completion forms for final typing and entry into the LEA database. The request form provides information on the types of final logs to be produced, the scale at which to plot the final forms, and notes common to all reports.

7. Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) procedures will be followed in compliance with the site-specific work plan.

8. References

8.1. EPA, *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER 9950.1, September 1986.

8.2 EPA, *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*, EPA/600/4-89/034, 1989.

8.3 Geoprobe, *Geoprobe® 0.5-in x 1.4 in OD and 0.75 in x 1.4 in OD Prepacked Screen Monitoring Wells, Standard Operating Procedure*, Technical Bulletin No. 962000, September 1996, revised; June 2002.

END OF DOCUMENT

ATTACHMENT 1

Monitoring Well Completion Report and Well Development Forms

WELL COMPLETION REPORT

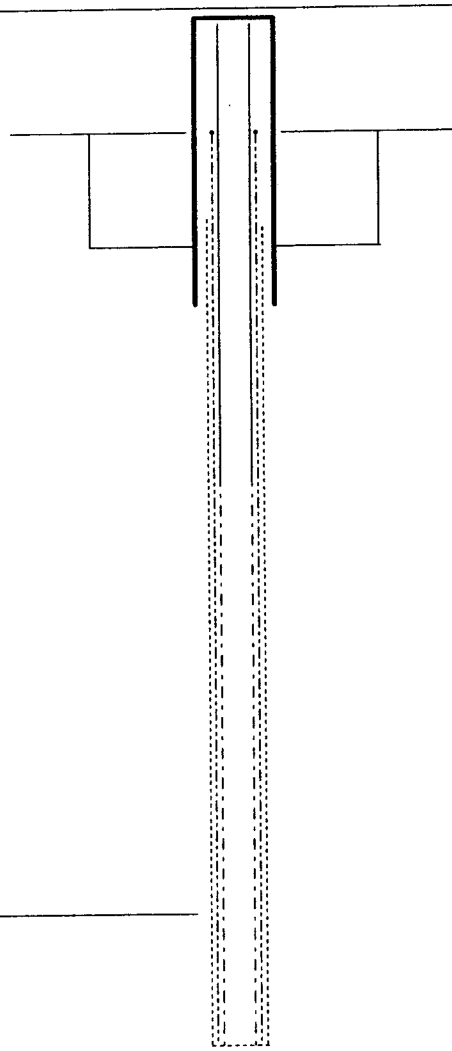
Project:
LEA Comm. No.
Client
Location ______________
Drilling Contractor ______________
Drilling Method ______________
Sampling Method ______________
Groundwater Observation
Depth ______ **at** ______ **Hours**

Start Date
End Date
Well ID

Logged by
Drilling Foreman ______________
Drill Rig ______________
GPS Latitude ______________
GPS Longitude ______________

Protector
- Material ______________
- Diameter ______________
- Length ______________
- Stickup ______________
- Key # ______________
- Cover Type ______________

Ground



Top Seal
- Top ______________
- Bottom ______________
- Material ______________

Backfill
- Top ______________
- Bottom ______________
- Material ______________

Secondary Sand
- Top ______________
- Bottom ______________
- Size ______________

Filter Pack
- Top ______________
- Bottom ______________
- Material ______________

Reported depth to bottom of boring ______________

Comments

Concrete Diameter ______________
Concrete Thickness ______________

Reference
- Stickup ______________
- Description ______________

Casing
- Diameter ______________
- Material ______________
- Length ______________
- Stickup ______________

Seal
- Top ______________
- Bottom ______________
- Material ______________

Screen
- Top ______________
- Bottom ______________
- Material ______________
- Diameter ______________
- Length ______________
- Slot Size ______________

Miscellaneous Materials (Quantity Used/Item)
- Cement ______________
- Bentonite Chips ______________
- Bentonite Pellets ______________
- Bentonite Powder ______________
- Grout Weight ______________
- Filter Pack Sand ______________
- Capping Sand ______________
- Well Point ______________
- Well Plug ______________

Signature ______________

Loureiro Engineering Associates, Inc.

Loureiro Engineering Associates, Inc.

FIELD SAMPLING RECORD
WELL DEVELOPMENT

LEA Comm. No.
Project
Location
Client

Page _____ of _____
Date ___/___/___
Time ___:___

Monitoring Well Number ________________ Sample Number(s) ______________ ______________

Initial Field Data and Measurements

Depth of Well ______________
Depth to Water ______________
Height of Column ______________

Reference Used ______________________
PID/FID Reading ______________
Interface Yes / No If yes, Depth __________ Lighter / Heavier

Well Casing Diameter ______________
Protector Road Box / Stickup
Ground to Reference ______________
Comments ______________________________________

Material ______________

General Condition	OK	Bad
Casing Secure		
Collar Intact		
Cover Locked		
Other (describe)		

Development Information

Purge Volume Factors
0.5" - 0.01
1" - 0.041
1.5" - 0.091
2" - 0.16
4" - 0.65
6" - 1.5

Initial Sample Observations
- Clear ☐
- Colored ☐
- Cloudy ☐
- Turbid ☐
- Odor ☐
- Sheen ☐

Parameter / Volumes	Gallons	Temp (C)	pH (SU)	Spec.Con.	Turbidity	Other
Initial						

Developement Method Peristaltic Pump / Bailer / Inertial Pump / Other ______________________

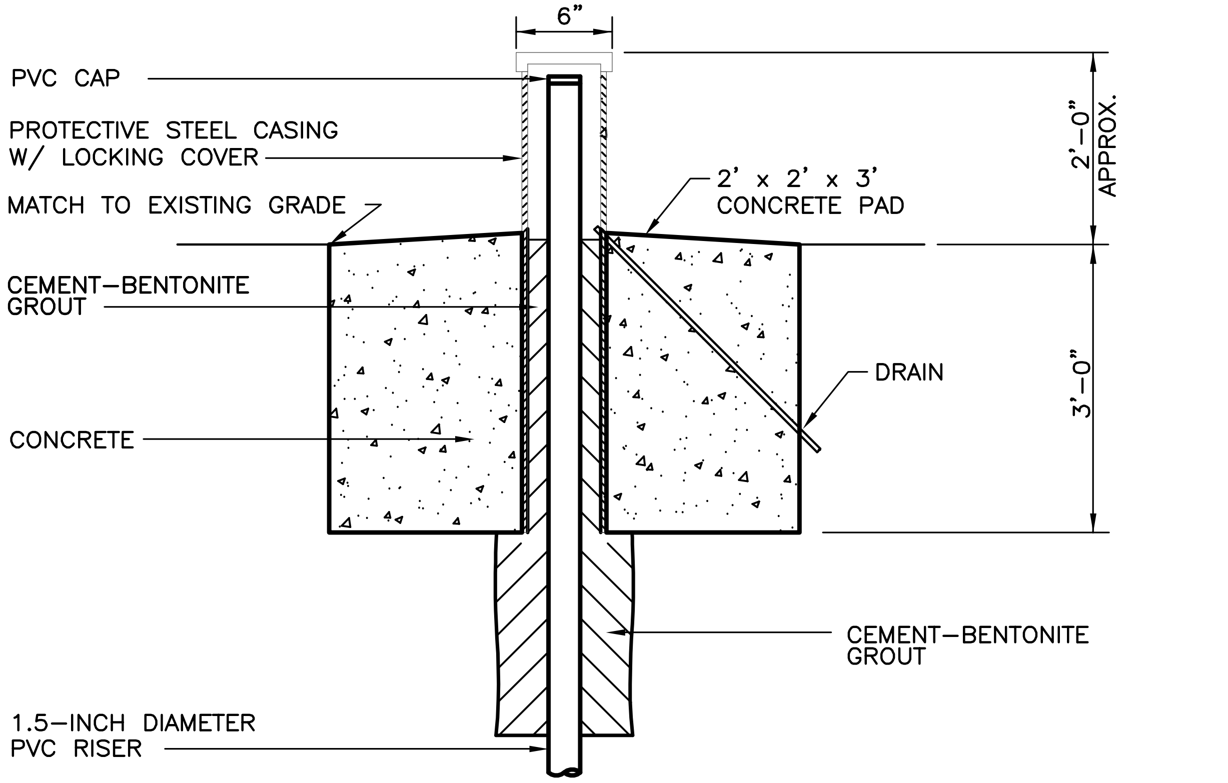
Field Decontamination? Yes / No If Yes, with what? ______________________

Waste Container ID ______________

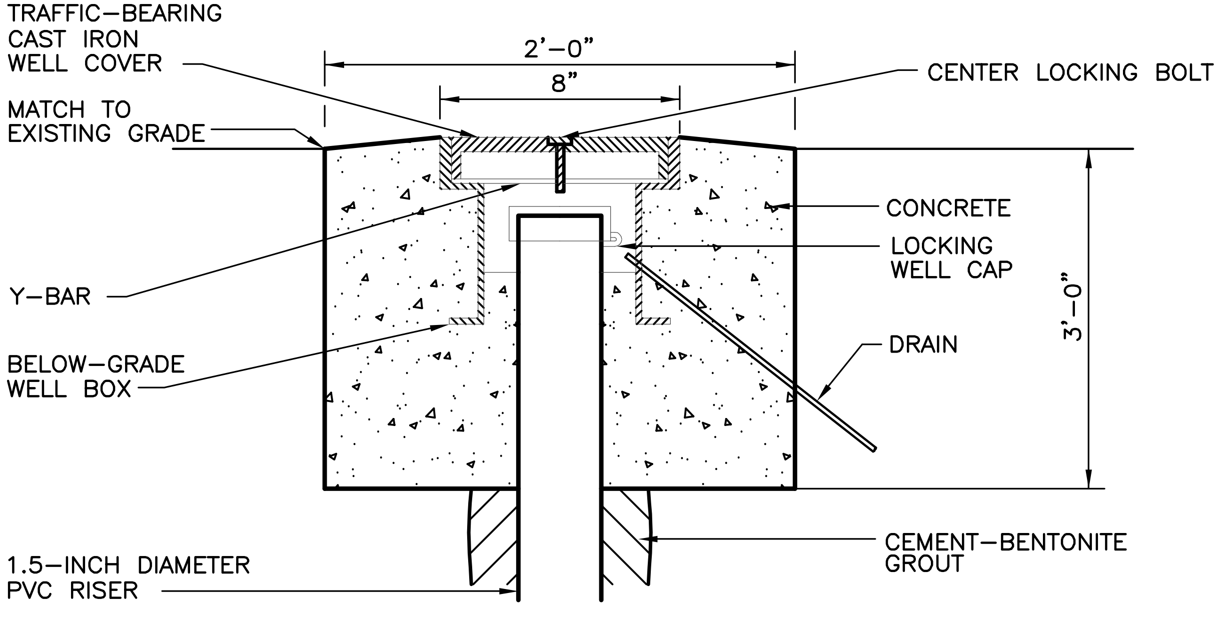
Additional Comments

Field Personnel ______________ ______________ ***Signature*** ______________

FIGURES



ABOVE GRADE WELLHEAD
CONSTRUCTION DETAIL – NOT TO SCALE



FLUSH TO GRADE WELLHEAD
CONSTRUCTION DETAIL – NOT TO SCALE

REFERENCES:

EPA, "RCRA GROUNDWATER MONITORING TECHNICAL ENFORCEMENT GUIDANCE DOCUMENT", OSWER 9950.1, SEPTEMBER 1986.

EPA, "HANDBOOK OF SUGGESTED PRACTICES FOR THE DESIGN AND INSTALLATION OF GROUNDWATER MONITORING WELLS", EPA/600/4–89/034, 1989.

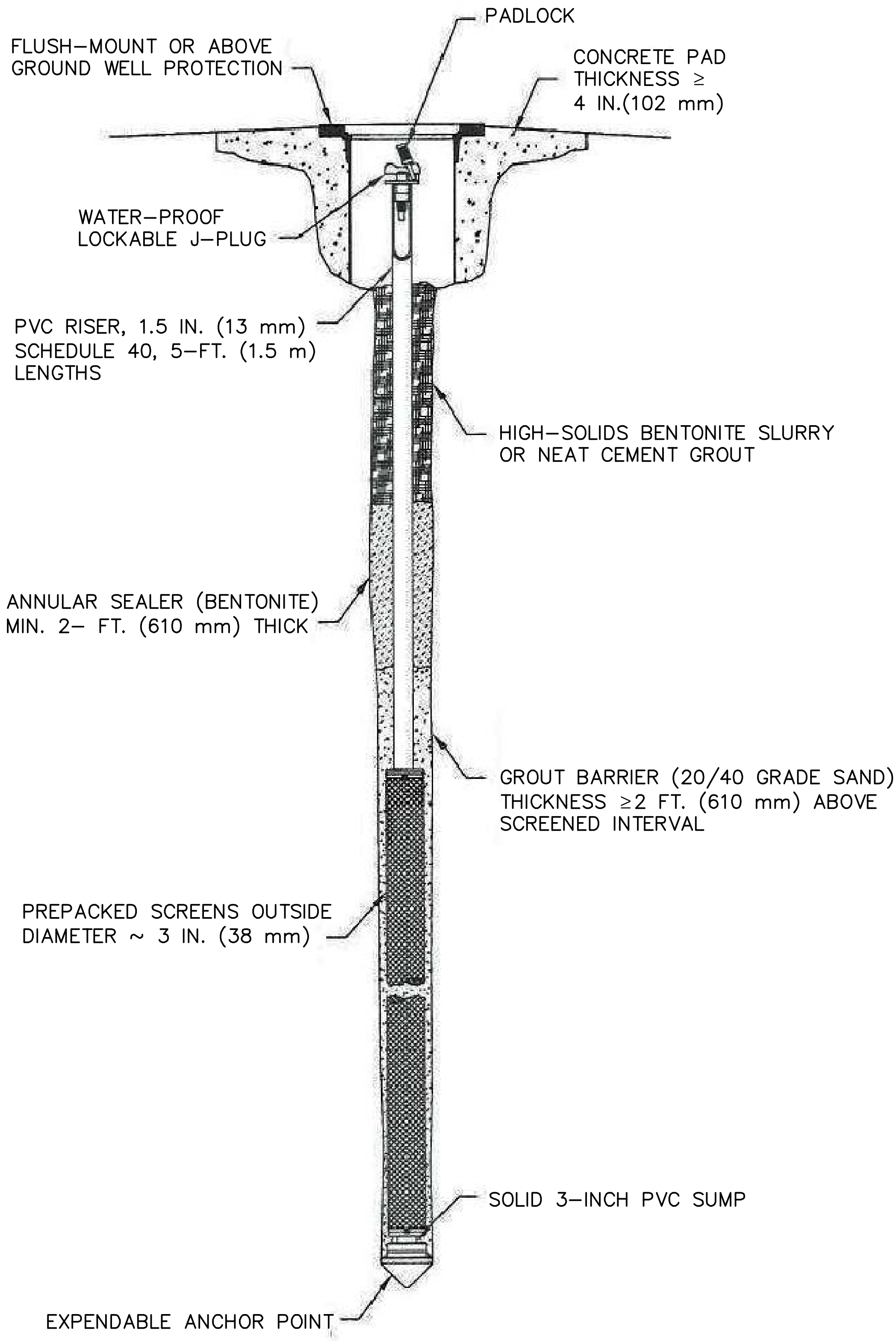
LEA SOP for Installing & Developing Monitoring Wells & Piezometers

TYPICAL WELLHEAD DETAILS
Modified March 2008

Comm.No. 100

FIGURE 1

LEA



ADAPTED FROM "GEOPROBE ® SYSTEMS – THE COMPLETE PROBING SYSTEM", TECHNICAL BULLITEN 99250, AUG. 1999, REVISED DEC. 2002.

LEA SOP for Installing & Developing Monitoring Wells & Piezometers

COMPLETED PRE–PACKED SCREEN WELL

Modified March 2008

Comm.No.		
100	**FIGURE 2**	LEA

G:\AUTOCAD\PROJECTS\0000100\SOPS\PREPACK–SCREEN–WELL.DWG Tab:REV MARCH 2008 Saved: 3/5/2008 2:16 PM Plotted: 3/5/2008 2:20 PM

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Low Flow (Low Stress)
Liquid Sample Collection and Field Analysis

SOP ID: 10039
Date Initiated: 06/11/01
Revision No. 003: 04/01/05

Approved By:	***/s/ David C. Brisson***	***04/01/05***
	David C. Brisson	**Date**
	Project Geologist	
	/s/ Gail Batchelder	***04/01/05***
	Gail L. Batchelder	**Date**
	Technical Director, Hydrogeology	
	/s/ Nick D. Skoularikis	***04/01/05***
	Nick D. Skoularikis	**Date**
	Director of Quality	

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	06/11/01	
001	04/01/02	Updated to reflect new SOP format.
002	12/02/02	Updated to reflect stabilization procedures.
003	04/01/05	Incorporated modified low-flow sampling procedure to include the use of a peristaltic pump.

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
For
Low Flow (Low Stress)
Liquid Sample Collection and Field Analysis

1. Purpose and Scope

This standard operating procedure (SOP) describes the procedures to be followed for measurement of static water level elevations, detection of immiscible layers, well evacuation, sample withdrawal, and field analyses utilizing low flow sampling techniques.

2. Definitions

2.1. Immiscible layers: The term is used to denote free-phase liquids that may be present in the aquifer as a result of a release. These liquids may have a density lighter than water (light non-aqueous phase liquids (LNAPL) or floaters) or heavier than water (dense non-aqueous phase liquids (DNAPL) or sinkers).

3. Equipment

3.1. Equipment required for the collection and field analysis of liquid samples shall include:

- Water-level indicator (accurate to 0.01 foot).
- Distilled water.
- Hand towels.
- Portable volatile organic compound (VOC) analyzer (Photovac MicroTIP®, Foxboro OVA® or equivalent).
- Interface probe/clear view bailer (to check for light non-aqueous phase liquids only).
- Flow-through cell capable of monitoring pH, temperature, specific-conductance, oxidation reduction potential (Eh), dissolved oxygen (DO), and turbidity.
- Polyethylene plastic sheeting.

- Adjustable rate submersible pump (preferred), adjustable rate centrifugal pump, bladder pump (constructed of stainless steel or Teflon®), or adjustable rate peristaltic pump
- Appropriate tubing for the pump used, for instance polyethylene tubing (1/4 to 3/8 inch outer diameter (O.D.)) for the peristaltic pump
- Clean disposable gloves.
- Alconox®, or other non-phosphate laboratory grade detergent.
- Three 5-gallon buckets.
- Decontamination brushes.
- Distilled, de-ionized (DI) water.
- Decontamination fluids (less than 10 percent methanol in water, 100 percent n-hexane, and 10 percent nitric acid).

4. Procedure

4.1. Health & Safety Requirements

All health and safety requirements described in the site specific Health & Safety Plan and/or Job Hazard analysis shall be observed

4.2. Equipment Decontamination

All materials and equipment that enter a well must be clean and free of any potential contaminants. Do not use any contaminated equipment or materials which are not designed to be used for groundwater monitoring, even if this means that the sampling will not be performed as planned.

In general, the choice of decontamination procedures should be based upon knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

4.2.1. Prior to commencing any field activities, the following solutions (as appropriate for the appropriate contaminants) should be prepared and placed into 500-ml laboratory squirt bottles: less than 10 percent methanol in water; 10 percent nitric acid in water; 100 percent n-hexane; distilled, de-ionized water.

4.2.2. In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

4.2.3. Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The plastic should be bermed to contain spills.

4.2.4. The order for decontaminating equipment is as follows:

1) Detergent scrub.
2) DI water rinse.
3) Hexane rinse (to be used only if separate-phase petroleum product, other than gasoline, is present).
4) DI water rinse.
5) 10 percent nitric acid rinse (to be used only when metals are suspected as potential contaminants).
6) DI water rinse.
7) Methanol rinse (less than 10 percent solution).
8) Air dry.

4.2.5. Materials such as the bailer cord should not be decontaminated and should just be disposed of after each test. Note: Bailers should be used **only** to check for LNAPL before sample collection using low-flow/low stress procedures. A bailer may be used to check for DNAPL only **after** all sample collection equipment has been removed from the well.

4.2.6. Wrap each piece of decontaminated equipment in aluminum foil, as appropriate, to maintain cleanliness.

4.2.7. At the end of the project day, dispose of all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment in accordance with all applicable municipal, state, and federal regulations.

4.3. Sample Collection

4.3.1. Immediately upon opening the well, the air in the well head will be sampled for VOCs using a portable VOC analyzer, such as a Photovac

MicroTIP® or equivalent. The instrument shall be zeroed with ambient air prior to the measurement, and the highest reading observed shall be recorded for each well. Measurements should be taken until stabilization of the readings has occurred.

4.4. Detection of Immiscible Layers

4.4.1. Should evidence warrant, a sampling event shall include provisions for the detection of immiscible phases prior to well evacuation or sample collection. LNAPLs are relatively insoluble liquid organic compounds with densities less than that of water (1 g/ml), while DNAPLs are organic compounds with densities greater than that of water. Lighter and/or denser immiscible phases may be encountered in a groundwater monitoring well.

4.4.2. An interface probe will be used to determine the existence of any immiscible layers, light or dense. Alternatively, a clear fluorocarbon resin or PVC bailer may be used to determine the existence of the phases or oil sheen in the well when no accurate determination of the immiscible layer thickness is required. As noted above, efforts to detect LNAPL only can be performed prior to sample collection. Efforts to detect DNAPL can be performed only AFTER sample collection has occurred.

4.4.3. Should elevations of the immiscible layers be required, levels of the fluids shall be measured to an accuracy of 0.01 feet using an electronic interface probe capable of detecting the interfaces between air, product, and water. The interface levels shall be recorded in the field form. Adjustments of the observed head to the theoretical hydraulic head shall be calculated based on the density conversion factor associated with the particular non-aqueous phase liquid.

4.4.4. If LNAPL is detected in a well, collection of a groundwater sample from that well is not recommended unless otherwise specified in the site-specific work plan or work instruction. However, if a groundwater sample must be collected from that well, low-flow sampling is the recommended technique, although care must be taken to minimize mobilization of the LNAPL into the zone from which the sample will be collected.

4.5. Measurement of Static Water Level

4.5.1. The static water elevations in each well shall be measured prior to each sampling event. This is performed initially to characterize the site, and in subsequent sampling rounds to determine whether horizontal or vertical flow gradients have changed. A change in hydrologic conditions may necessitate modification of the groundwater monitoring program.

4.5.2. Remove the protective cover and locking cap from the well.

4.5.3. Each well shall have a surveyed reference point located at the top of the well casing with the locking cap removed. The reference point shall be easily recognizable, since the personnel conducting the sampling may differ from one sampling event to the next.

4.5.4. The following parameters shall be measured with an accuracy of 0.01 ft:

- Depth to standing water.
- Depth to bottom of well.

4.5.5. A water-level indicator with a fiberglass tape will be used for measurement. As a result of possible pressure differences between the well atmosphere and the ambient atmosphere, the water level will be allowed fifteen minutes to equilibrate upon removal of the well cap. If excess pressure is encountered the water level will be allowed greater than fifteen minutes to equilibrate upon removal of the well cap. The results shall be recorded on the appropriate field form(s).

4.5.6. Total depth measurements will be compared to original depths to determine the degree of siltation that may have occurred. This information shall be noted on the field forms. Should significant siltation occur in any well, the well shall be redeveloped by an approved method.

4.5.7. The portion of the tape immersed in the well shall be decontaminated during retrieval using a distilled water rinse followed by drying with a clean wipe, prior to use in another well. This decontamination procedure shall be amended, as needed, to accommodate the specific type of contamination anticipated.

4.5.8. The static water level should be monitored and recorded throughout the purging and sampling of each well.

4.6. Field Analysis

4.6.1. Parameters that are physically or chemically unstable shall be tested utilizing a flow-through cell. Such parameters as pH, temperature, specific conductance, DO, Eh, and turbidity will be measured in the field at the temperature of the well sample.

4.6.2. Parameters such as pH, temperature, specific conductance, DO, and Eh shall be measured using a flow-through-cell (YSI model 6820 or equivalent). The meter shall be calibrated prior to use and at the end of the day using supplied solutions in accordance with the instructions provided by the manufacturer. Calibration information will be recorded in the field before and after each calibration.

4.5.3 Turbidity can be measured with a separate turbidimeter, although some flow-through cells include a turbidimeter. It is useful to have a separate turbidimeter on hand to check the validity of the turbidity values obtained using the flow-through cell if there is difficulty reaching low turbidity values or if the turbidity readings recorded do not seem to be consistent with visual observation of the water samples. All samples, including turbidity samples and samples to be submitted for analysis, must be collected before the groundwater passes through the flow-through cell to prevent cross-contamination by potentially stagnant fluid within the flow-through cell. This can be accomplished by using a bypass assembly or disconnecting the tubing from the flow-cell inlet prior to sampling.

4.7. Well Evacuation

4.7.1. Calculate standing water in the well based on the following schedule and record on the appropriate field form:

Well Diameter (inches)	Conversion Factor (gal/feet)
2	0.163
4	0.654
6	1.47

4.7.2. Generally, a submersible, air-lift, bladder, or peristaltic pump equipped with appropriate tubing of inert materials (such as polyethylene), shall be used to evacuate the monitoring wells.

4.7.3. A new piece of polyethylene plastic shall be placed on the ground adjacent to the well. Sampling and purging equipment such as the pump, tubing, containers, etc., shall be placed on the polyethylene sheet, never on the ground.

4.7.4. The pumps and tubing shall be prepared for insertion into the well while wearing disposable gloves. Make sure that any tubing or pump apparatus is of sufficient length to reach the appropriate depth for pumping.

4.7.5. Lower the pump and/or tubing gently into the water column to the midpoint of the saturated portion of the screened interval, unless otherwise specified. A site-specific sampling plan should specify the sampling depth, or provide specific criteria for the selection of intake depth for each well. If possible keep the pump intake two feet above the bottom of the well. Start the pump at the lowest speed setting and slowly increase the speed until discharge occurs. The initial pumping rate shall be approximately 0.1 liters per minute, however, the pumping rate shall not exceed 0.25 liters per minute. Measure the water level to ensure that drawdown in excess of 0.3 feet does not occur in the well. Adjust the pumping rate as necessary until little or no drawdown occurs. If the drawdown exceeds 0.3 feet, reduce pumping rate if possible. If drawdown still does not stabilize at a depth above the pump intake, shut the pump down and allow the well to recharge. It should be noted that stable drawdowns of 0.3 feet are desirable but not mandatory. Stabilization of the drawdown to a depth greater than 0.3 feet is acceptable as long as the depth at which stabilization occurs is above the pump intake. However, it is important that the stabilization depth is clearly recorded and maintained.

4.7.6. Monitor and record the water level and pumping rate at a minimum of every five minutes during purging. Calculate the volume of the discharge tubing, bladder pump (if used), and the flow-through cell. Monitor and record indicator field parameters (turbidity, pH, Eh, DO, temperature and specific conductance) in the well from the first water extracted during the purging process and at least every five minutes thereafter. Stabilization is considered to be achieved when three consecutive readings are within the following limits and no increasing or decreasing trend in the data can be observed:

- Turbidity (10% for values less than 5 and greater than 1 NTU). It should be noted that achievements of turbidity levels less than 5 NTUs are not mandatory but efforts should be made to collect a groundwater samples with the lowest turbidity achievable.
- DO (10%, measured as milligrams per liter).
- Specific Conductance and Temperature (3%).
- pH (+/- 0.1 unit).
- ORP/Eh (+/- 10 millivolts).

4.7.7. If after 2.5 hours of purging or the purging of three well volumes, (whichever comes first) the field parameters have not stabilized, purging may be discontinued to allow sample collection. Similarly, if it is not possible to obtain stabilization as described above as a result of slow recovery of the well, the well shall be evacuated and allowed to recover, at which point the samples should be collected immediately. The appropriate sampling forms shall include a notation that sample collection occurred without stabilization. Samples obtained from slow-yielding wells shall be collected as soon as a sufficient volume is available for a sample for each parameter.

4.7.8. Do **not** re-use purging equipment. Pumps shall be decontaminated between monitoring wells, in accordance with procedures noted in Section 4.1.

4.7.9. Record sampler's name, sampling time, volume of water purged, parameters measured, weather conditions, sample number, analyses required and all other pertinent information in the field notebook and/or appropriate field forms, and complete the chain of custody form.

4.7.10. Any water purged from the monitoring wells shall be stored in appropriate containers until the laboratory analyses are available. Then it should be disposed of in accordance with all applicable local, state and federal requirements.

4.7.11. Storage shall be in containers approved for storage of hazardous materials, and in an appropriate designated location at the facility.

4.8. Sample Withdrawal

4.8.1. In order to ensure that the groundwater sample is representative of the formation, it is important to minimize physical alteration (i.e. agitation during purging and/or sample collection) or chemical contamination of the sample during the withdrawal process.

4.8.2. Use an appropriate pump to purge each well; the same pump used for purging shall be used for sample withdrawal.

4.8.3. The samples shall be collected at a location before entering the flow-through cell. To minimize the effects of water column agitation on sample quality, samples shall be collected from the pump tubing in the following order into pre-labeled sample containers:

- VOCs.
- Total petroleum hydrocarbons.
- Extractable organics (semivolatiles).
- PCBs.
- Metals.
- Phenols.
- Cyanide.
- Chloride and sulfate.
- Nitrate and ammonia.
- Turbidity.
- Radionuclides.
- Purgeable organic carbon (POCs).
- Purgeable organic halogens (POX).
- Total organic halogens (TOX).
- Total organic carbon (TOC).

4.8.4. Samples shall be obtained from the monitoring wells as soon as possible after purging. This may require waiting an extended period for low-yielding wells.

4.8.5. Samples collected for VOC analysis shall be free of any air bubbles and inverted upon filling. Bacterial samples shall be collected using dedicated gloves; taking care not to allow anything to touch the inside of the sampling container.

4.8.6. Samples collected for metals analysis, which are to be filtered in the field, shall be passed through an appropriately sized filter prior to placement in the sample bottle. Pre-rinse the filter with approximately 25 to 50 milliliters of groundwater prior to collecting the filtered metals sample. Filter sizes will generally be either 0.45 microns for dissolved metals and 10 microns for metals that could be present as colloids or adsorbed onto colloids that could be mobile in the aquifer. The appropriate filter size for the individual project must be provided in site-specific work instructions.

4.9. "What If" Scenarios

4.9.1. Certain field conditions may be encountered that influence the choice of equipment to be used or altogether limit the feasibility of low-flow sampling techniques. The following is a brief description of select scenarios to provide field personnel with a guideline if similar circumstances are encountered

4.9.2. Turbidity

4.9.2.1. If turbidity measurements do not stabilize as described above after 2.5 hours of purging or the evacuation of three well volumes, whichever comes first, sample collection can be initiated. Record observations of the color, clarity, and other observable characteristics of the groundwater (such as the presence or absence of particles) in the field paperwork

4.9.2.2. If samples are being collected for analysis for total (unfiltered) metals and the turbidity has not stabilized below 10 NTU, a sample for additional analysis for metals should also be collected after being filtered in the field through an in-line 10-micron filter, if specified in the work instructions.

4.9.3. Peristaltic Pump

4.9.3.1. Difficulty may be encountered while advancing the flexible polyethylene peristaltic pump tubing to the desired depth within a deep well or older well. Excessive friction may result from the tubing contacting the sidewall of the well casing or accumulations of material on the well casing (i.e. mineral and bacterial deposits). In these scenarios, the tubing may coil within the well during advancement and prevent the desired depth from being attained. Efforts to weight the tubing should be attempted before using alternate pumping techniques.

4.9.3.2. If such well conditions are expected, a bladder pump or similarly submersible pump should be used instead of a peristaltic pump. A bladder pump provides sufficient mass on the tubing to allow for advancement in deep or older wells.

4.9.3.3. A peristaltic pump cannot be used to sample wells in which the depth to water is greater than approximately 25 feet.

4.9.4. Sampling Depth

4.9.4.1. If conditions exist that prevent the appropriate pump or tubing from being advanced to the midpoint of the saturated portion of the screened interval, low-flow sampling techniques shall not be used. Instead, sampling shall be conducted using conventional purging and sampling techniques, as described in LEA SOP 10004 entitled *Liquid Sample Collection and Field Analysis*. Justification for not using low-flow sampling techniques must be provided in the field paperwork.

4.10. Field Documentation

4.10.1. Field documentation shall include at a minimum: a chain-of-custody form, Field Data Record Groundwater Form, Sample Collection Form, Daily Field Report. Sample labels and sample seals shall be used for proper sample identification.

4.10.1.1. The labels shall be sufficiently durable to withstand immersion for 48 hours without detaching and to withstand normal handling. The information provided shall be legible at all times.

4.10.1.2. The following information shall be provided on the sample label using an indelible pen:

- Sample identification number.
- Date and time of collection.
- Place of collection.
- Parameter(s) requested (if space permits).

4.10.1.3. Appropriate field forms will be used to log all pertinent information with an indelible pen. The following information shall be provided:

- Project and site identification.
- LEA commission number.
- Identification of well.
- Static water level measurement technique.
- Presence of immiscible layers and detection method.
- Time well purged.
- Collection method for immiscible layers and sample identification numbers.
- Well evacuation procedure/equipment.
- Sample withdrawal procedure/equipment.
- Date and time of collection.
- Types of sample containers used and sample identification numbers.
- Preservative(s) used.
- Parameters requested for analysis.
- Field analysis method(s).
- Whether or not field filtration was performed and the filter size, if appropriate.
- Field observations on day of sampling event.
- Record of site activities.
- Field personnel.

- Climatic conditions, including air temperature.
- Status of total production.
- Record of non-productive time.

4.10.1.4. The Field Sampling Record shall include at a minimum the following information:

- Identification of well.
- Date and time of collection.
- Name of collector.
- Sample number.

4.10.1.5. The chain-of-custody record shall include the following information:

- Company's name and location.
- Date and time of collection.
- Sample number.
- Container type, number, size.
- Preservative used.
- Signature of collector.
- Signatures of persons involved in the chain of possession.
- Analyses to be performed.
- Type and number of samples.

4.10.1.6. The Field Data Record Groundwater Form shall be updated during the sampling of each well and include the following information:

- Identification of well.
- Well depth, diameter, depth to water.
- Static water level depth and measurement technique.
- Purge volume and pumping rate.
- Time well is purged.

- Measurements of initial field parameters and all subsequent readings.
- Any specific circumstances, as described above, such as field filtering, lack of stabilization of parameters, water characteristics, etc.
- LEA commission number.
- Date.

4.10.1.7. The Daily Field Record shall include the following information:

- Client's name, location, LEA commission number, date.
- Instrument make, model, and type.
- Calibration readings.
- Calibration/filtration lot numbers.
- Field personnel and signature.

4.10.1.8. The Daily Field Record shall assure the completeness of the sampling round and include the following information:

- Reviewer's name, date, and LEA commission number.
- Review of all necessary site activities and field forms.
- Statement of corrective actions for deficiencies.

5. References

5.1. United States Environmental Protection Agency (EPA), Region I. *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells,* July 30, 1996, Revision 2.

5.2. EPA. *Groundwater Sampling Guidelines for Superfund and RCRA Project Managers – Groundwater Forum Issue Paper,* Office of Solid Waste and Emergency Response, (EPA 542-S-02-001), May 2002.

5.3. Robert W. Puls and Michael Barcelona, EPA. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures,* in Groundwater Issue, (EPA/540/S-95/504), April 1996.

5.4. Connecticut Department of Environmental Protection, Bureau of Water Management, Permitting Enforcement and Remediation Division. *Site Characterization Guidance Document,* Draft, June 12, 2000.

END OF DOCUMENT

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Quality Assurance/Quality Control Measures
for
Field Activities

SOP ID: 10005
Date Initiated: 02/20/90
Revision No. 004: 12/31/01

Approved By: ***/s/ Jeffrey J. Loureiro*** ***12/19/01***
Jeffrey J. Loureiro **Date**
President

/s/ Nick D. Skoularikis ***12/19/01***
Nick D. Skoularikis **Date**
Director of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	02/20/90	
001-003	-	No record.
004	12/31/01	Updated to reflect new SOP format. Added section 4.3, Results Evaluation. Minor revisions throughout.

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Quality Assurance/Quality Control Measures
for
Field Activities

1. Statement of Purpose

This document describes procedures to be followed for proper Quality Assurance Quality Control (QA/QC) practices which shall incorporate all activities associated with sampling tool and instrument preparation, field measurements and sampling, proper documentation of field and post-field activities, QC sample preparation, chain-of-custody protocol and laboratory analytical procedures. The use of specific QA/QC measures is project-specific as defined in the project work plan. This standard operating procedure (SOP) was adopted in accordance with the Environmental Protection Agency (EPA) document *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846).

2. Definitions

2.1. Trip Blank: An aliquot of organic-free water or equivalent neutral reference material carried into the field but not exposed.

2.2. Equipment Blank: An aliquot of analyte-free deionized water processed through all sample collection equipment.

2.3. Replicate Samples: Samples that have been divided into two or more portions in the field.

2.4. Collocated Samples: Independent samples collected under identical circumstances in a way that they are equally representative of the parameter of interest.

2.5. Performance Evaluation (PE) Sample: A sample that mimics actual samples in all possible aspects, except that its composition is known to the auditor and unknown to the analyst.

3. Equipment

None

4. Procedure

4.1. General

4.1.1. All QA/QC sample preparation procedures shall be properly documented including:

- Name of person(s) or laboratory involved in sample preparation.
- Reagents used.
- Sample number.
- Analyses required.
- Concentration calculations.
- Accuracy of measurements.
- Number, type, size of containers used.
- Preservation method.
- Date and time of sample preparation.

4.1.2. All information shall be included in the field logbook and/or appropriate field forms, but not necessarily in the chain-of-custody record except as needed for proper sample identification and analysis. Blind sample numbers are being used in order not to disclose the nature of the sample to the laboratory. No information that would identify the sample as a QA/QC sample shall be included in the chain-of-custody record.

4.1.3. At the conclusion of each sampling day, a quality control review shall be conducted using the Field Quality Review Checklist and the Daily Field Report.

4.2. QC Sample Preparation

4.2.1. Trip Blank

4.2.1.1. Contaminated trip blanks may indicate contamination of the samples during the field trip or shipment to the lab, cross-contamination between the samples, contaminated sample vials, or improper handling.

4.2.1.2. Trip blanks shall be used only with samples that are to be analyzed for volatile organic compounds.

4.2.1.3. One trip blank shall be included per shipping container (cooler) carrying sample soil and/or groundwater samples that are to be analyzed for volatile organic compounds

4.2.1.4. Trip blanks are prepared using analyte-free deionized organic-free water prior to field activities associated with the sampling event, usually by the laboratory providing the sampling containers. Each trip blank is placed in a 40-ml glass VOA vial and is carried in the same shipping container as the sample(s). Trip blanks should not be opened at any time during transport.

4.2.2. Equipment Blank

4.2.2.1. The purpose of an equipment/rinsate blank is to determine if decontamination procedures were adequate or if any of the equipment might contribute contaminants to the sample.

4.2.2.2. An equipment blank is prepared by running analyte-free deionized water through all sample collection equipment (bailers, pumps, filters, split-spoon) and placing it in the appropriate sample containers for analysis. If equipment has been decontaminated in the field, the equipment blank shall be collected after decontamination procedures have been performed.

4.2.2.3. Equipment blanks shall be used when sampling surface water, groundwater, soil, and sediment.

4.2.2.4. One equipment blank shall be collected for each sample bottle/preservation technique/analysis procedure per matrix per sampling event, or as otherwise specified in project-specific documents.

4.2.3. Replicate Samples

4.2.3.1. Replicate samples provide precision information on handling, shipping, storage, preparation and laboratory analysis.

4.2.3.2. Replicate samples are samples that have been divided into two or more portions in the field. An example of a replicate sample is two identical sample bottles filled with water from the same bailer retrieval. To ensure homogeneity, the bailer should be emptied into a clean, decontaminated beaker used exclusively for the purpose and containing sufficient volume for both sample containers, and from that into the sample containers.

4.2.3.3. Replicate samples cannot be used when sampling for volatile organic compounds.

4.2.3.4. One replicate sample shall be obtained for each sample bottle/preservation technique/analysis procedure per sampling event or one out of every 20 samples, unless collocated samples are used (see below), or as otherwise specified in project-specific documents.

4.2.4. Collocated Samples

4.2.4.1. Collocated samples provide precision information on sample acquisition, homogeneity, handling, shipping, storage, preparation and laboratory analysis.

4.2.4.2. Collocated samples are independent samples collected in such a way so that presumably they are equally representative of the parameter of interest. Examples of collocated samples are groundwater samples collected sequentially, soil core samples collected side-by-side, or air samples collected essentially at the same time from the same manifold.

4.2.4.3. Collocated samples are especially useful when sampling for volatile organic compounds, for which replicate samples cannot be used.

4.2.4.4. Collocated samples shall be obtained for each sample bottle/preservation technique/analysis procedure per sampling event or one out of every 20 samples, unless replicate samples are used (see above), or as otherwise specified in project-specific documents.

4.2.5. Split Samples

4.2.5.1. The purpose of split samples is to provide an assessment of the laboratory analytical procedure.

4.2.5.2. Split samples are collocated or replicate samples sent to two (or more) different laboratories.

4.2.5.3. Split samples can be used with any sample media. Split samples can be used in conjunction with spiked samples (see below). In case contradictory results are obtained from the samples split between different laboratories, the spiked samples can be used to verify the analytical data (provided that the spiked samples were properly prepared and the appropriate documentation is available).

4.2.5.4. When used, one split/spiked sample per sample bottle/preservation technique/analysis procedure per sampling event or every 20 samples shall be included, or as specified in project-specific documents.

4.2.6. Spiked Samples

4.2.6.1. The purpose of spiked samples is to provide information on the precision of the laboratory analytical procedure. However, besides a wrong preparation, several other sources of error exist such as analyte stability, holding time and interactions with the sample matrix.

4.2.6.2. Spiked samples are samples spiked with the contaminants of interest. The compounds used for spiking should be of the same chemical group as the contaminants being investigated, but they do not have to be the exact chemical compounds. Spiking should be carefully designed and performed prior to the field investigations. Field matrix spikes are not generally recommended because of the high level of technical expertise required for proper preparation and documentation.

4.2.6.3. Can be used with any sample media, however, liquid matrices are preferred due to uniformity of mixing.

4.2.6.4. When used, one split/spiked sample per sample bottle/preservation technique/analysis procedure per sampling event or every 20 samples shall be included, or as otherwise specified in project-specific documents. In order to ensure defensible data, performance evaluation (PE) samples, prepared by an independent vendor, are typically being used. The ordering and handling procedures and record keeping requirements are discussed in Loureiro Engineering Associates, Inc. (LEA's) *SOP for Preparation of PE Samples* (SOP 10030).

4.3. Result Evaluation

4.3.1. The analytical results on QA/QC samples should be evaluated along with the remaining analytical data as follows:

4.3.1.1. No constituents should be detected in the trip blank or equipment blank.

4.3.1.2. The relative percent differences (RPDs) shall be computed for all constituents detected in both duplicate samples used.

The RPD between two measurements (e.g., M1 and M2) is calculated as follows:

$$RPD = \frac{|\, M1 - M2 \,|}{(\, M1 + M2 \,)\,/\,2} \; x \; 100\%$$

4.3.1.3. Any deviations in the performance evaluation samples shall be brought to the attention of the laboratory. An investigation shall then be performed by the laboratory of the method used, laboratory QA/QC procedures followed, and computations performed. The laboratory shall report the results of their investigation and any corrective actions taken.

5. References

5.1. EPA, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846).

END OF DOCUMENT